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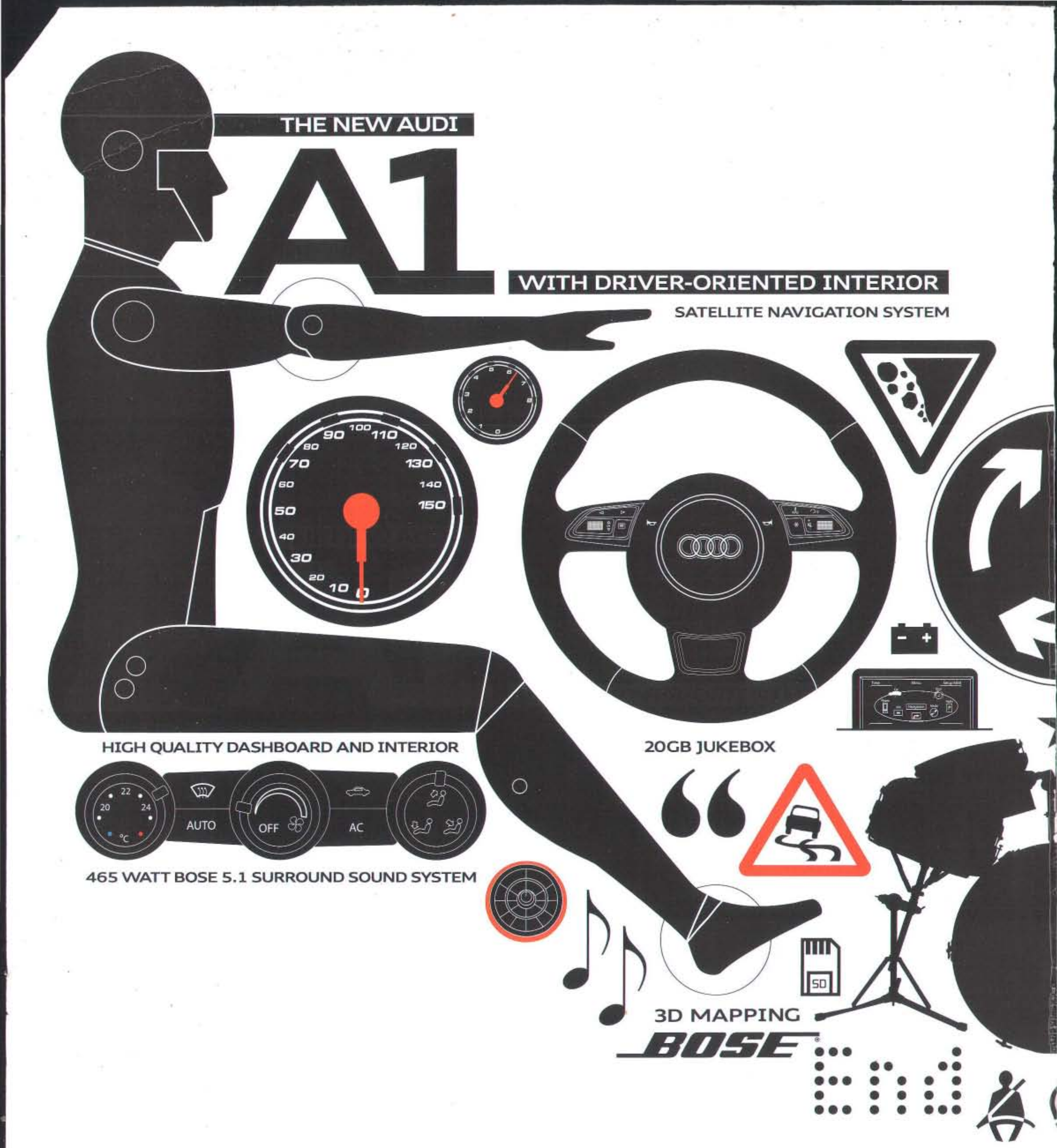
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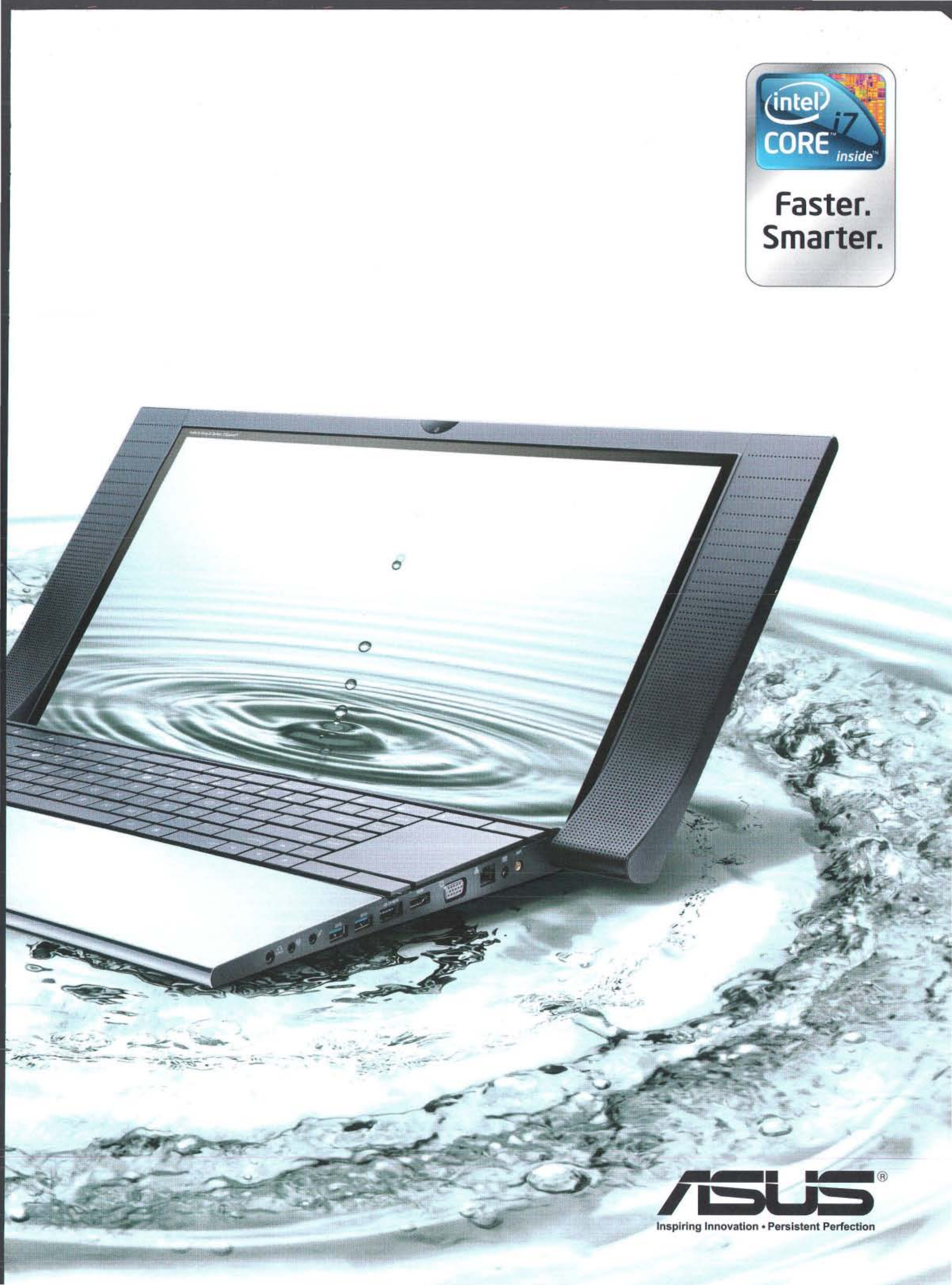
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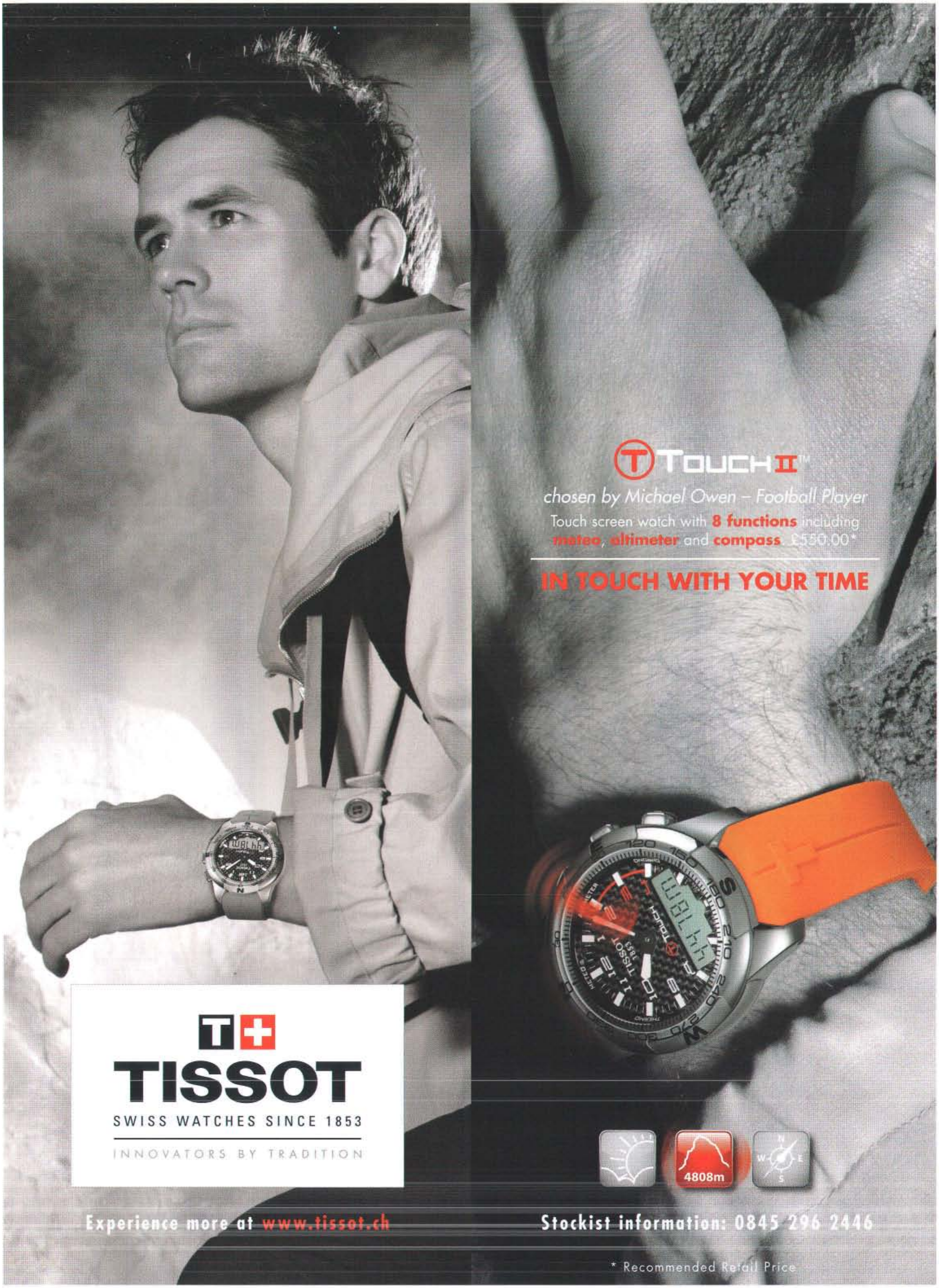

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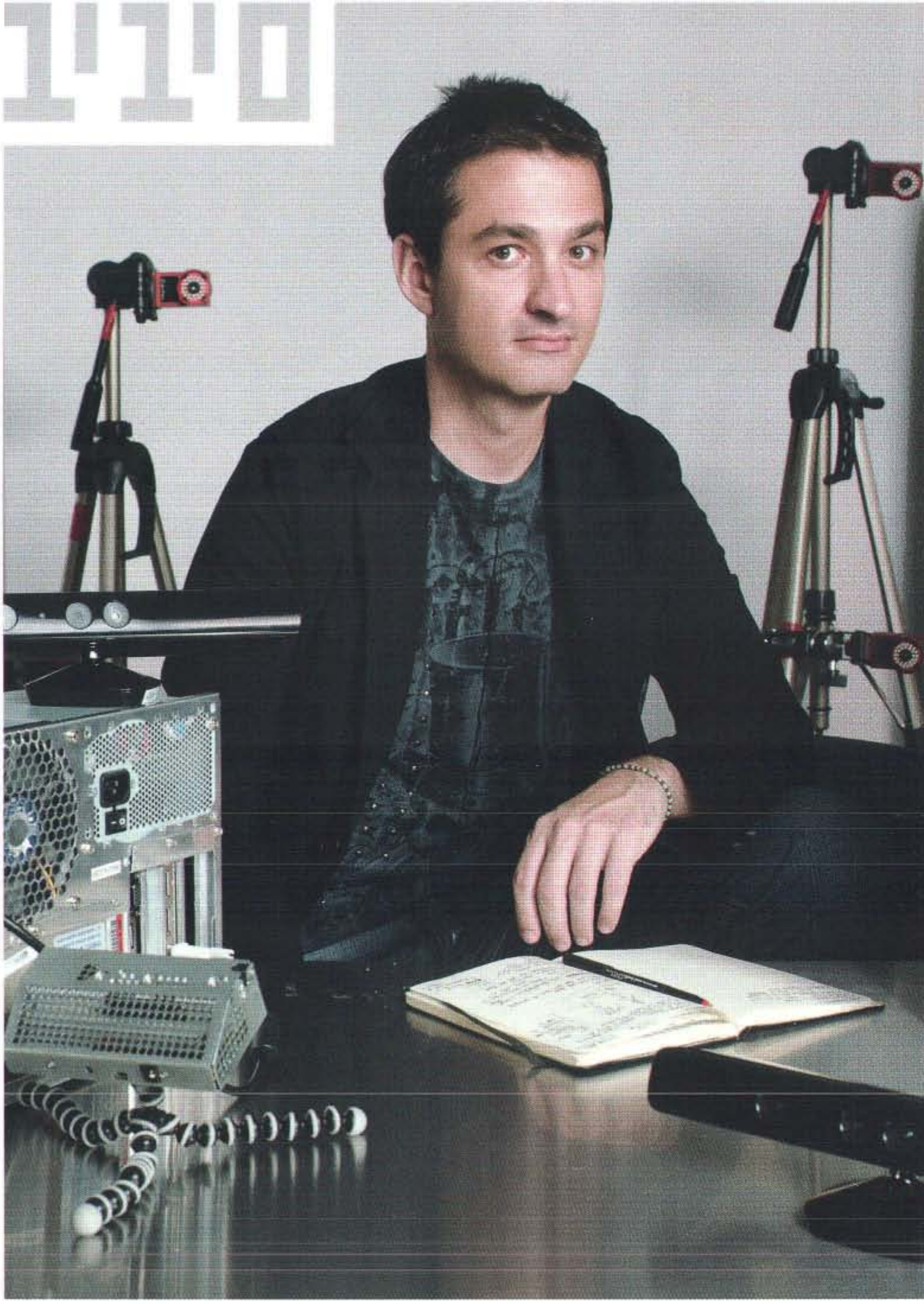

Alex Kipman – the man who incubated Project Natal for Microsoft's Xbox 360 team

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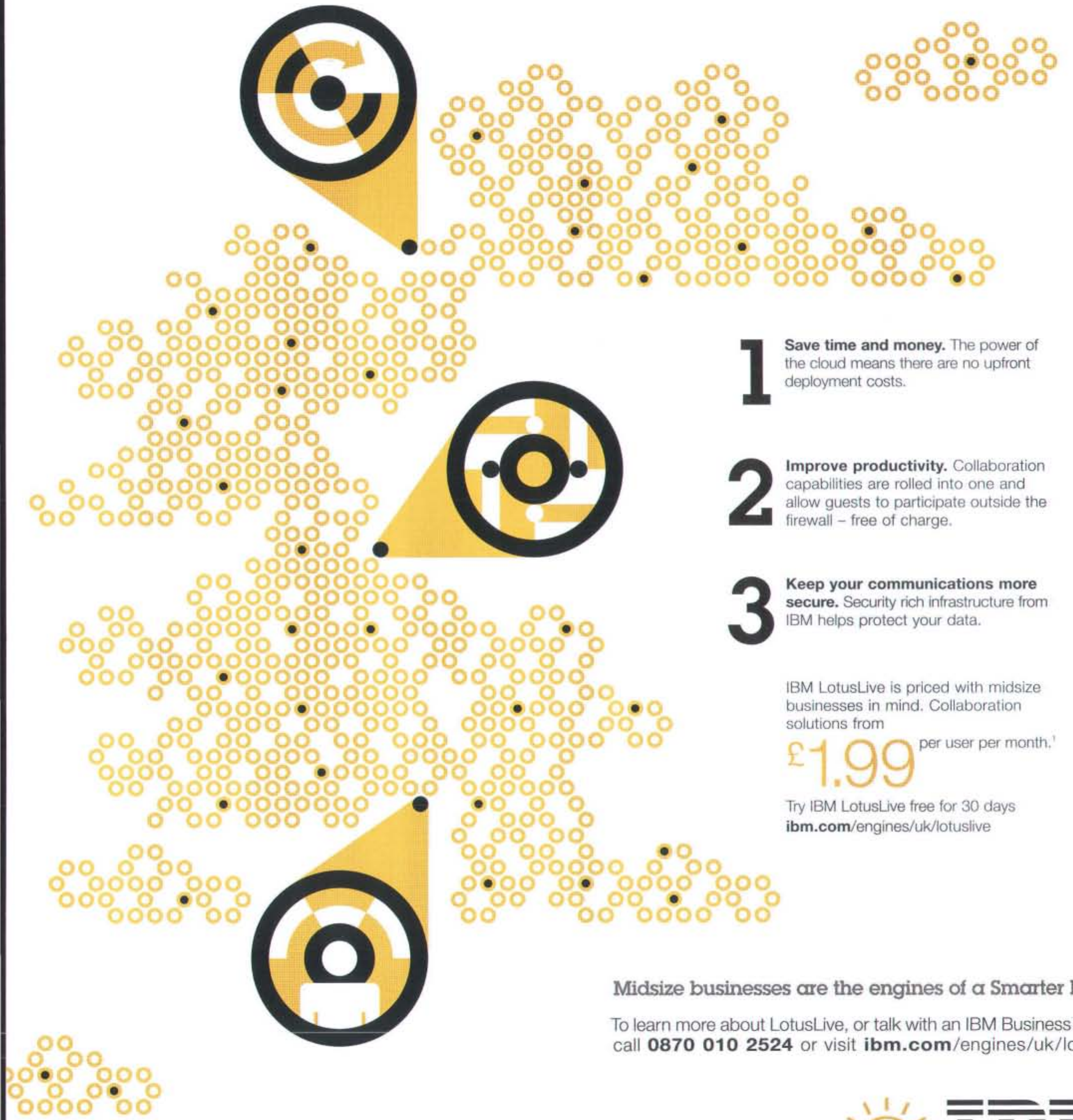

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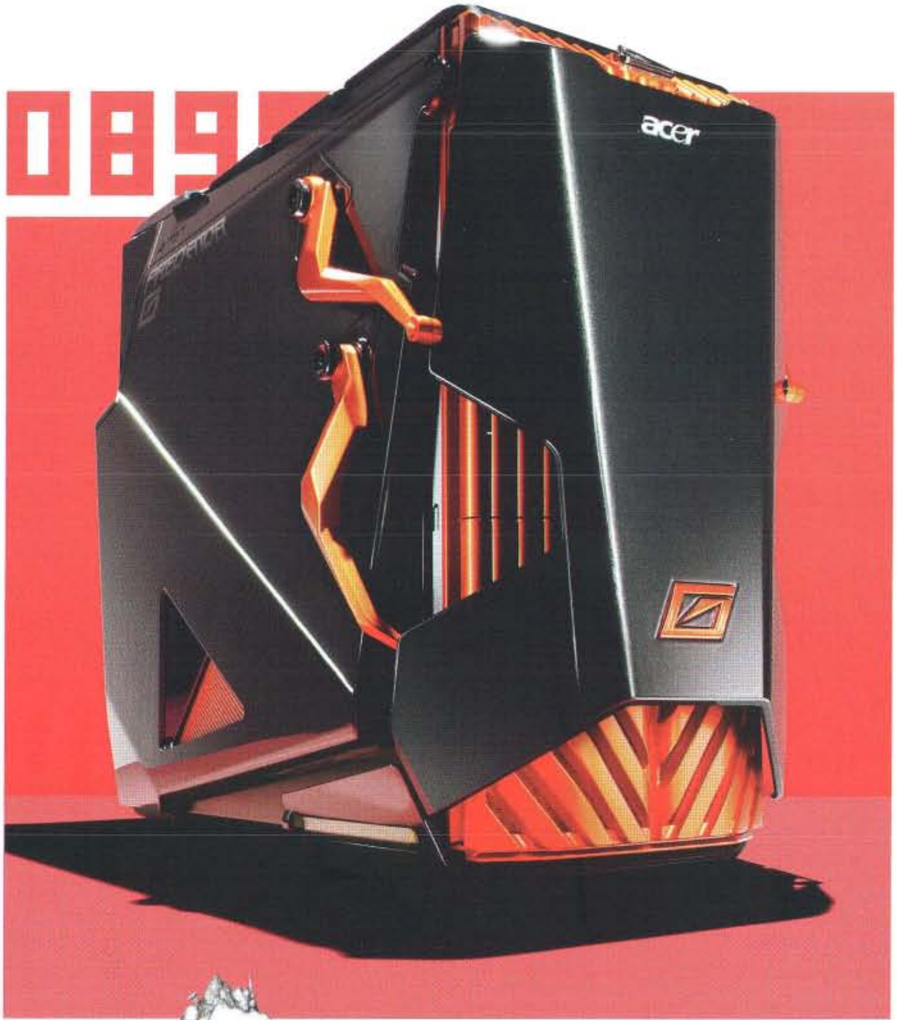

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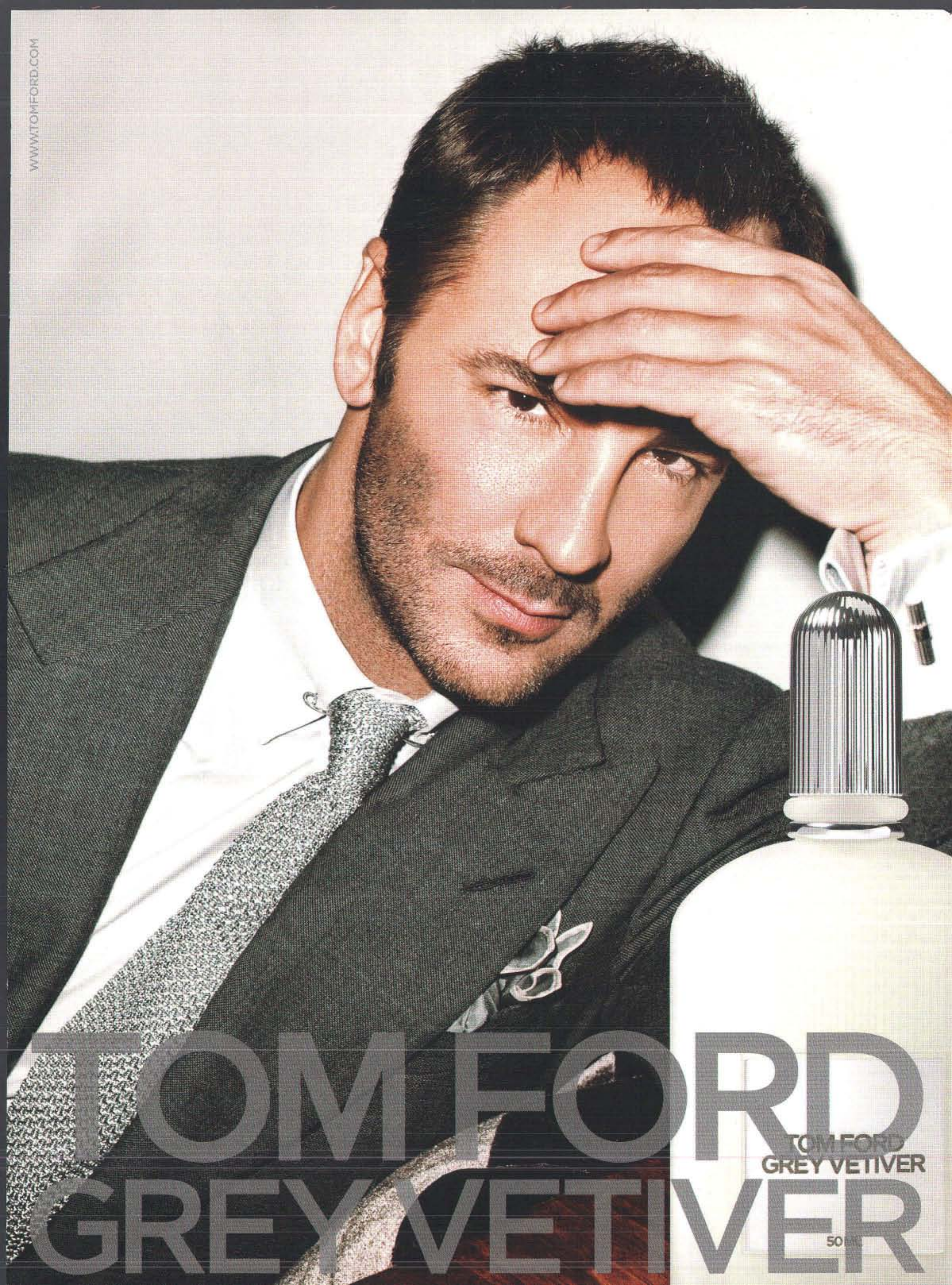
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10.10
Watch out, Silicon Valley

Announcing our feature on Europe's new wave of tech entrepreneurs, last month's cash-like cover inspired a flood of reader response

Issue 18, as a word cloud
Amid a certain amount of self-reference, the message to European start-ups was none too subtle: "people make new million now"

RANTS 11.10

WHAT YOU THOUGHT OF OUR EIGHTEENTH ISSUE

CONTACT US: RANTS@WIRED.CO.UK

ON THE MONEY

"Europe's Next Billion Dollar Start-Ups; The Web is Dead; Your Next Car Will Run On Hydrogen": Yay, it's @WiredUK's Doomed Predictions issue!
@flashboy

That cover is on the money.
Shailesh Ladwa, by email

Is it legal tender?
@snoochies

I love the little details (iPad in the crest), but where's the watermark?
@hoquew

Your October cover is easily your best yet, although I do like the tactile grainy ones better than the smooth.
@geoffpugh

Magazine piracy is getting worse. @WiredUK takes drastic measure for latest cover.
@acton

That issue is so pretty. Every time I go to staple something, I want to touch it. Or just gaze at it. Or whisper sweet nothings at it.
@MeganGeuss

SEEING (RED)

I get a little disappointed when I read articles like "FTW in Africa" (Start, 08.10). What people such as Bill Gates, Bono, Angelina Jolie and now Seb Bishop are doing is perpetuating Africa's poverty. Africa no longer needs handouts to "fight Aids". What Africa needs is for that money to be invested in creating businesses that will employ people and create wealth to sustain itself and join the mainstream global economy. Selling toys and sending 20p to Africa really is an insult. If Bishop and co want to help, then come here to Nairobi, set up a business and employ people.
Alvas Onguru, by email

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On the rails

It isn't true that National Rail Enquiries (NRE) refuses to open up its data feeds (Editor's letter, 09.10). We've opened up our data to a range of organisations, often free of charge, so they can provide information about trains.

From the popular iPhone app to providing live departure and arrival times for Network West Midlands' interactive transport map, we have and will continue to make our data available to third parties, so train travellers can have easy access to all the information that they need. NRE takes neither a penny of government subsidy nor makes a penny of profit. Our continued priority will be to provide people with correct, relevant and up-to-date information to get them from A to B.
Chris Scoggins, chief executive, National Rail Enquiries

I suspect that the closed approach of National Rail Enquiries is less about the "practicalities" of making it available and more about being held accountable and the potential negative impact on revenue – in the form of customer claims.

National Rail Enquires is owned by the Association of Train Operating Companies – which most train operators have an interest in. Most offer compensation for delays. If it were possible for everyone to view historical performance data, just imagine how many season-ticket holders would claim that they were on "that" train that was delayed for 45 minutes... Scary stuff for train operators.
James Herrieven, by email

I'm signing up for your campaign for the PM to threaten to withdraw public subsidy to the Association of Train Operating Companies to open up their feeds.
David J Simpson, by email

The phat controller

You missed a trick in "Mix yourself a masterpiece" (Fetish, 10.10). Not to feature Novation's Dicer controller is a serious oversight. Any respectable Ableton or Serato user is at least aware of Dicer, or has one already.
Joe Burns, Disruptive Limited, by email

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11.10 contributors

Michael Hodges

WIRED sent Hodges to the Svalbard Seed Vault, located "on the wrong side of dismal", to explore the progress of this huge project. "It protects a resource all governments take seriously," he says. "Our future food supplies."

Jim Hill

Our Fetish special was ably assembled by Hill, who sought out the "technically interesting and truly innovative" from a massive range of products. So what was his favourite? "Easily the GoCycle. It's a triumph of design, with an obvious human benefit."

Mike Diver & Pedro Aguilar

The photographers captured the Kinect – the Xbox's interactive eye in our living rooms – for the cover feature. "We're all used to being watched by cameras now," says Diver. "We only need to worry if Kinect learns to read our thoughts."

Steve Boxer

"Conversing with in-game characters is huge progress," says Boxer, a London-based writer who looked at speech-recognition in gaming. "You can interact with real people over Xbox Live, but computer characters have always lagged."

Adam Higginbotham

Based in New York, Higginbotham met the scientist making wireless electricity a reality. "Nikola Tesla first envisioned wireless power in the 1890s," he says. "But the boom in personal electronic devices has revived it."

Beth Algieri & Jonny Plummer

YumYumLondon – aka Algieri and Plummer – design 3D CGI characters with a handcrafted feel. "The people we created for How To have big, fun personalities," says Plummer. "We want to do a short film next."

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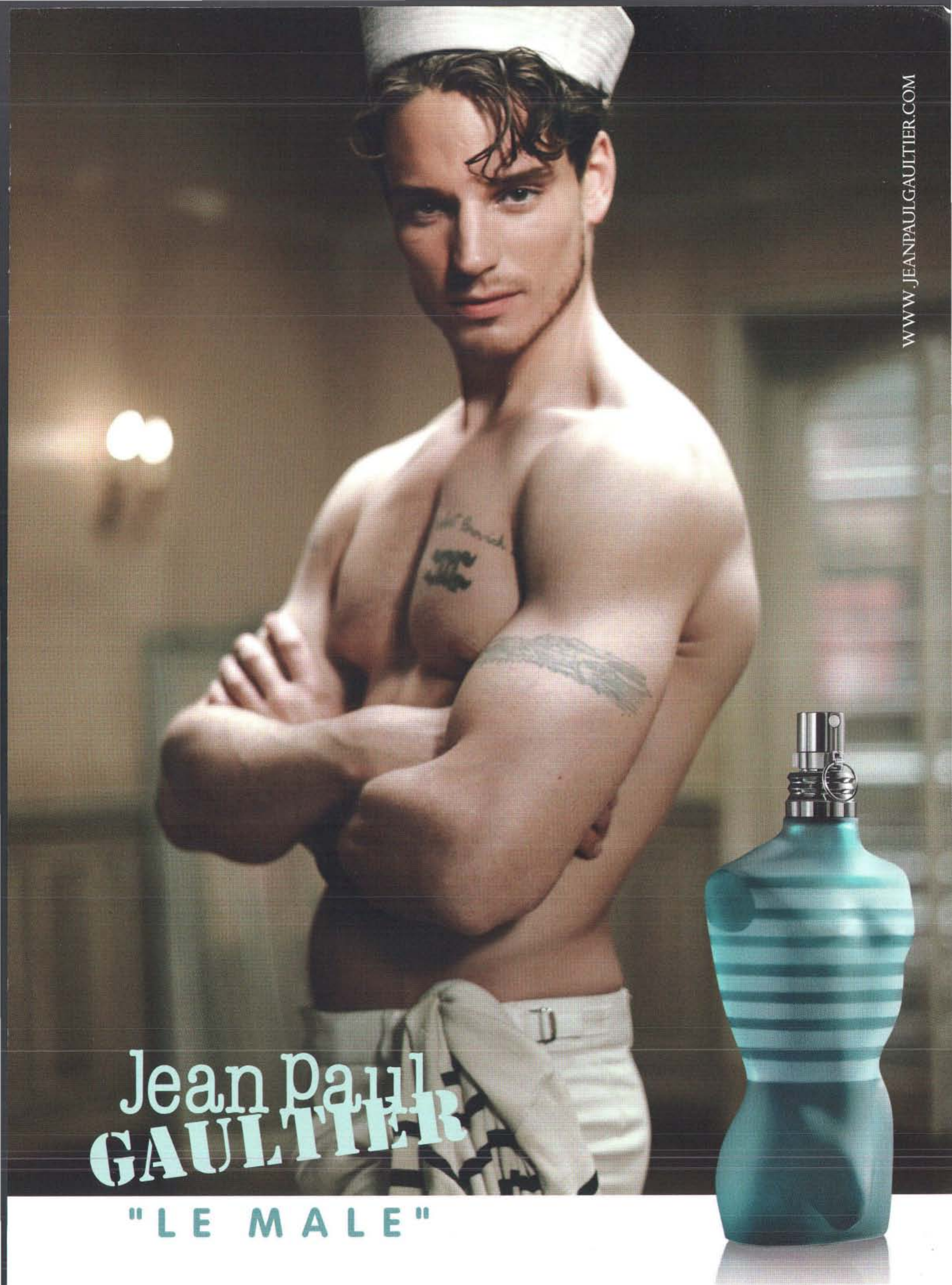
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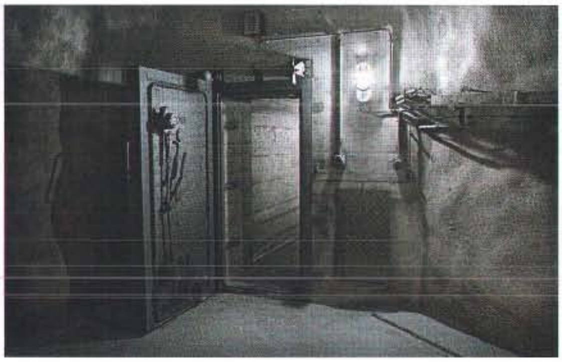
Above: Microsoft's Xbox 360 and its companion, Kinect (see p110)
Below, left: Swiss Fort Knox, the secure data-stronghold (see p120)

I'm in Cambridge, at Microsoft Research, and I'm looking at the future of man-machine interaction. The academics here – specialists in probabilistic maths and machine learning – have just cracked one of modern technology's great challenges: how to track people as they're moving so a computer appears intuitively to understand their actions. And though these softly spoken PhDs are too modest to say so, their work has huge implications in fields ranging from medicine to sport.

In the short term, the Cambridge research has allowed Microsoft to reinvent the Xbox 360 as a games console that does away with the controller. It's made possible the Kinect entertainment system that, from next month, will allow you to control racing cars, white-water rafts and footballs simply by moving your body. If families warm to it, there's no doubt that Kinect will give the Xbox the potential to reach a vast new mainstream audience and spawn a multi-billion-dollar franchise. But there's something else happening here that is of far greater long-term significance than gaming. We're entering a new era of "natural user interfaces", whereby intelligent machines respond to our physical presence, our gestures, even our moods. By recognising you and responding to your voice and your movements, these systems will help you learn guitar more effectively, improve your running technique, even rehabilitate you after an operation. They will know how hot to run your bath, change TV channels when you wave, and no doubt cook your eggs to your liking at your spoken command. My all-access cover story on the making of Kinect gave me huge respect for the creative innovators around the world who came together to make it work. But what really excites me is that vast range of possibilities that lie far beyond gaming.

BIG NEWS: Next month, you can enjoy WIRED on the iPad as well as on paper. Following on from the success of our American colleagues' groundbreaking WIRED US app, we'll be using enhanced multimedia to reinvent how we tell stories on the tablet screen. We've spent months planning everything from video to 360° panoramic photographs and animated infographics. Do join us at the App Store from early November.

PHOTOGRAPHY: DIVER & AGUILAR; TODD ANTONY



David Rowan, Editor

David Rowan

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- PPA Designer of the Year, Consumer 2010
- Maggies Technology Cover 2010

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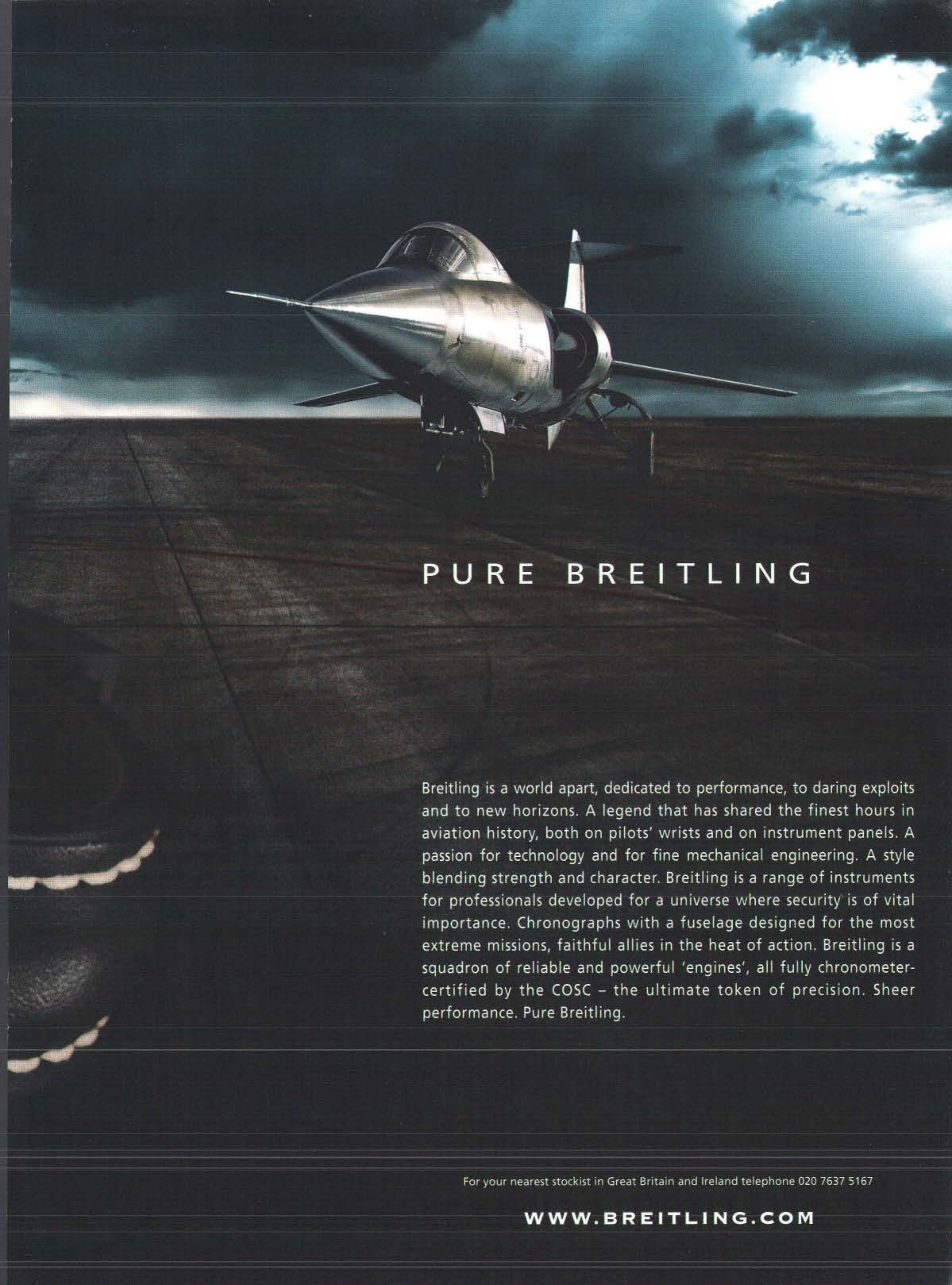

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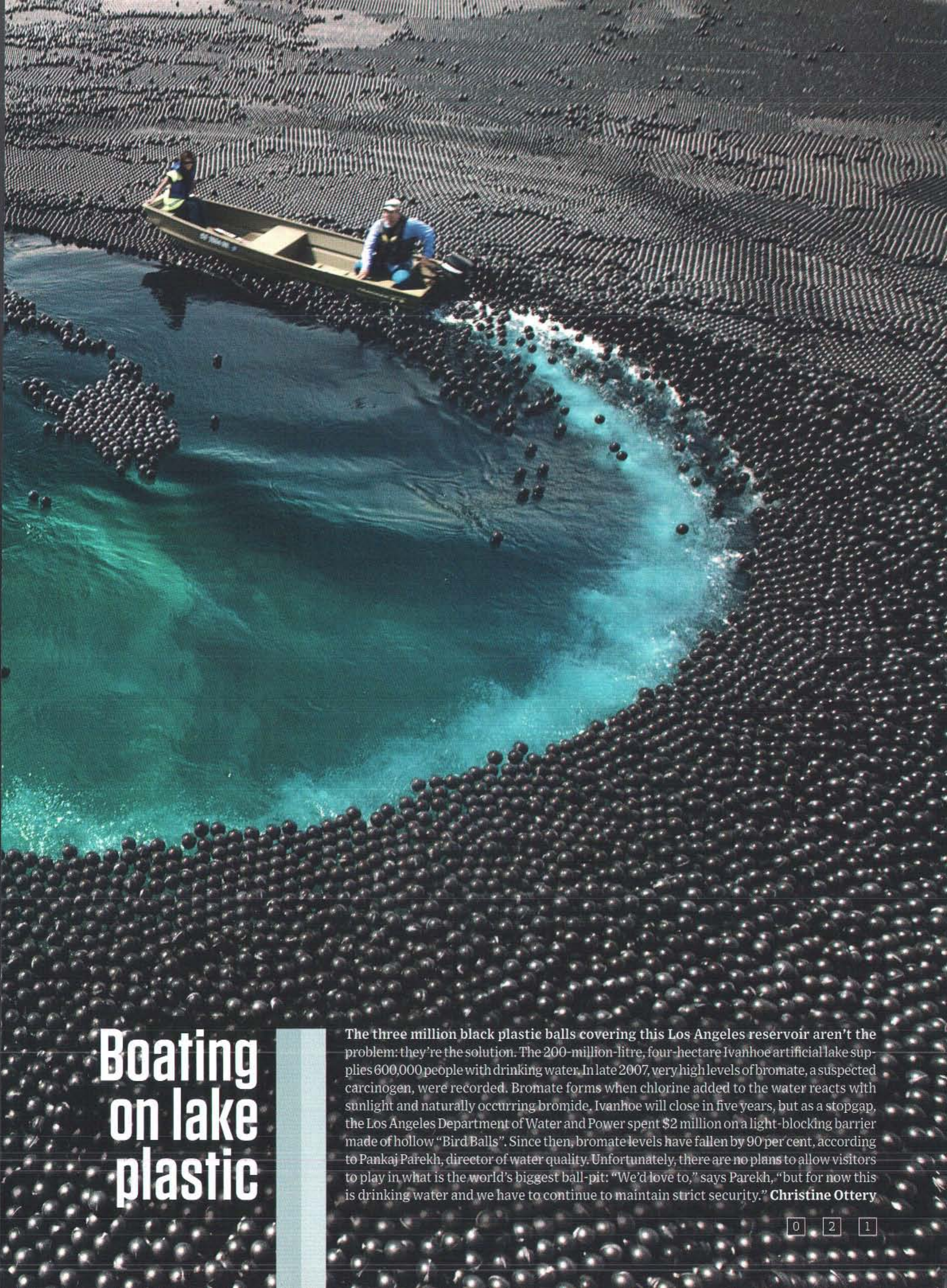

Boating on lake plastic

The three million black plastic balls covering this Los Angeles reservoir aren't the problem: they're the solution. The 200-million-litre, four-hectare Ivanhoe artificial lake supplies 600,000 people with drinking water. In late 2007, very high levels of bromate, a suspected carcinogen, were recorded. Bromate forms when chlorine added to the water reacts with sunlight and naturally occurring bromide. Ivanhoe will close in five years, but as a stopgap, the Los Angeles Department of Water and Power spent $2 million on a light-blocking barrier made of hollow "Bird Balls". Since then, bromate levels have fallen by 90 per cent, according to Pankaj Parekh, director of water quality. Unfortunately, there are no plans to allow visitors to play in what is the world's biggest ball-pit: "We'd love to," says Parekh, "but for now this is drinking water and we have to continue to maintain strict security." **Christine Ottery**

Long-life lipstick power

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THE SOLVENTS
To dissolve charged ions, in this case Li^+ and ClO_4^-, a solvent is required; but water reacts too violently. Propylene carbonate ($C_4H_6O_3$) works but needs diluting with dimethoxyethane ($C_4H_{10}O_2$). In other uses $C_4H_6O_3$ is a base for lipstick, and $C_4H_{10}O_2$ is used in pesticides.

THE ELECTROLYTE
This is the salt lithium perchlorate ($LiClO_4$) dissolved in a solvent and which provides a conducting medium between the anode and cathode.

MANGANESE DIOXIDE (MnO_2)
This compound solid has always been used in dry-cell batteries. MnO_2 occurs naturally, as pyrolusite, which is mined on a large scale but it must be processed to remove impurities before being incorporated into batteries. MnO_2 is also the black pigment commonly used in prehistoric cave paintings.

Each month WIRED's chemist Dr John Emsley, author of nine books and 110 research papers, deconstructs an everyday product. This month: Energizer lithium batteries

INGREDIENTS
>A positive electrode (anode) made of lithium
>A negative electrode (cathode) made of manganese dioxide and graphite
>An electrolyte of lithium perchlorate in a mixed solvent of propylene carbonate and dimethoxyethane

LITHIUM
The lightest of all metals, lithium is also used in greases, to treat bipolar disorder and in hydrogen bombs. In a battery, current is generated at the anode and the cathode, and involves a transfer of electrons.

The chemical reaction begins when the battery becomes part of an external circuit through which the electrons flow between electrodes. The lithium atoms release electrons to become positive ions (Li^+); the manganese atoms gain them, thereby going from Mn^{4+} to Mn^{3+}.

Lithium stearate is made from stearic acid, a fatty acid that's a component of most lubricant greases. It stays soft at temperatures as low as -60°C and is used on vehicles in the Antarctic. A component in hydrogen bombs is lithium hydride, in which lithium is the lithium-6 isotope and the hydrogen is the hydrogen-2 isotope, also known as deuterium.

PHOTOGRAPHY: MATTHEW SHAVE

< DATABASE: DATA WE LOVE This month, words filtered by Chinese search engine Baidu.com >

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SAMSUNG

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Nature's military draft

From bees to dolphins, the animal kingdom fights for Uncle Sam

Pelusium, 525 BC. The Persian army ends 2,500 years of dynastic rule in Egypt with a secret weapon: cats. When the advancing Persians release a cohort of kittens, Egyptian archers refuse to risk killing the sacred creatures and the city is taken without a fight. Flash forward to today and animals remain on the front line – although today's armies might prefer recombinant feline DNA shots to give troops an eight-life upgrade. WIRED unveils the latest military animals. **Mark Harris**

NAVY DOLPHINS
Atlantic bottlenose dolphins and California sea lions will patrol the waters off Seattle, to guard nuclear subs against terrorist swimmers. They are being trained to seek out underwater intruders using their biosonar.

HAPPY DOGS
The suicide rate among US veterans of the Iraq and Afghanistan wars is nearly double that of civilians. Now the US Army is using dogs to relieve some of the symptoms of post-traumatic stress disorder.

SNIFFING BEES
Scientists at the Los Alamos National Laboratory in New Mexico are developing a bee bomb-disposal unit (see WIRED 01.10). The RF-tagged bees, when fed a sugar solution flavoured with explosive, seek out buried mines.

CYBORG INSECTS
Scientists at the University of California can wirelessly control flower beetles with six micrometer-sized electrode stimulators implanted in their brains and muscles. Commissioned by the US government to build an insect spy army (bugs in both senses), the research showed that electrical pulses can be coded to communicate commands, such as "take off", "land" and "turn right".

NIKOLA TESLA'S PATENT REDUX

A magnetic-wave generator developed by Nikola Tesla over 100 years ago as a wireless communication device has been updated by engineers at Lockheed Martin to save lives after mining disasters. Magnetic waves – unlike radio waves – can penetrate hundreds of metres of solid rock. MagneLink (*left*), the fridge-sized device developed by Lockheed Martin, allows for phone calls and text messaging. It was tested this year at a mine in Virginia, and production is expected before 2011. **Frank Swain**

JARGON WATCH

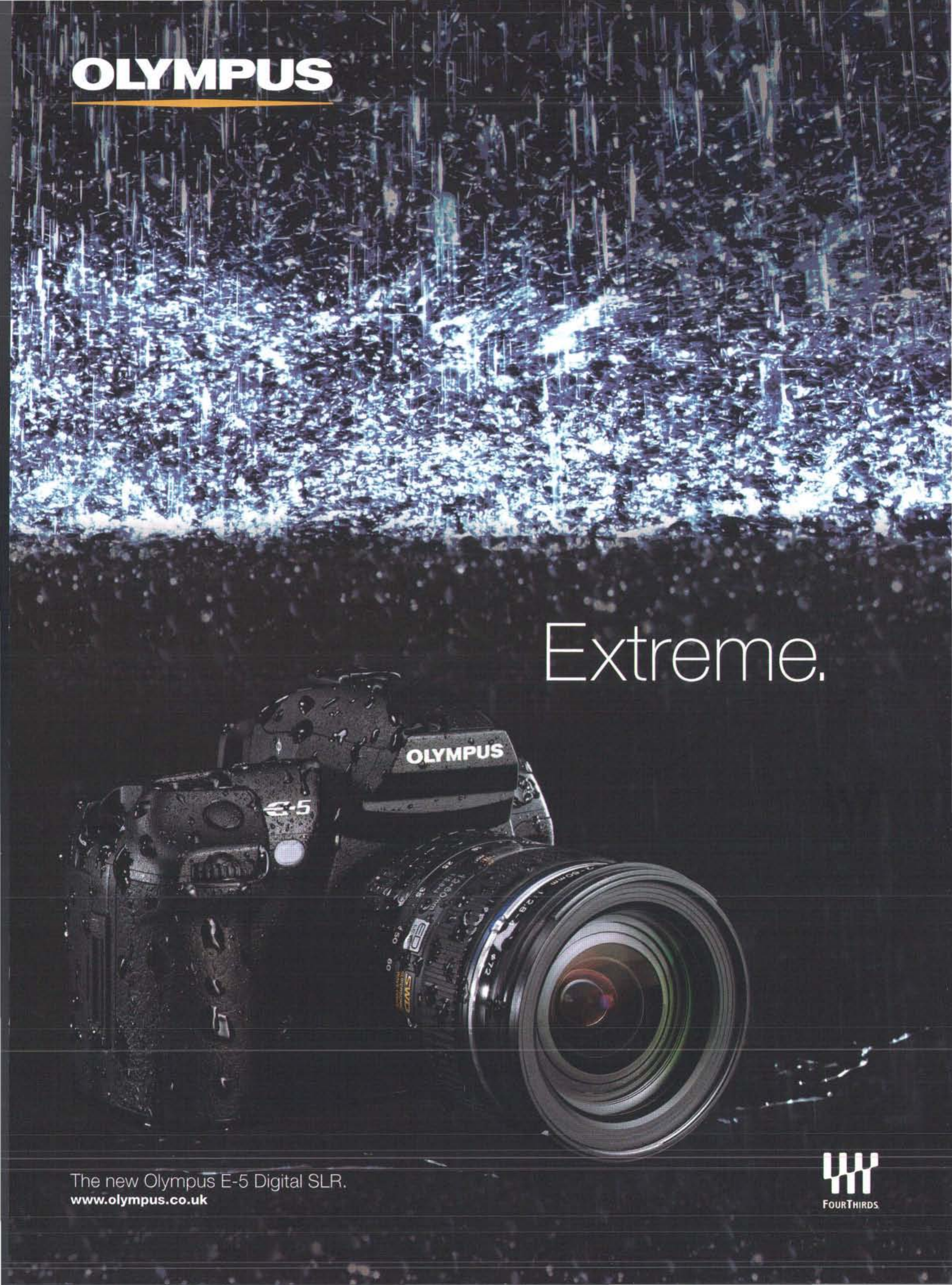
Bar inflation, n.
Showing more bars in a mobile phone's signal-strength indicator than are warranted by the strength. Shortly after releasing the iPhone 4, Apple said it was "stunned to find that the formula we use to calculate the signal strength is totally wrong".

Googlenope, n.
A phrase in inverted commas that returns no results when it's Googled. Invented by Gene Weingarten of the *Washington Post*, Googlenopes such as "Laura Bush's secret tattoo" and "The sensual feel of the speculum" are celebrations of the unlikely.

Deficit peacock, n.
A person who makes an ostentatious show of being opposed to government deficits, but does nothing to reduce those deficits. A similar bird is the climate peacock, who claims to be against man-made global warming, but then does nothing to alleviate the problem.

Wild kitchen, n.
An area abundant in berries, vegetables, mushrooms and other wild foods that can be foraged and consumed. Wild kitchens are often frequented by locavores (who eat only locally grown food), and freegans (vegans who consume only food obtained by foraging).
Paul McFedries

PHOTOGRAPHY: WENN; CORBIS; EYEVINE. ILLUSTRATION: MATT NEEDLE



The new Olympus E-5 Digital SLR.
www.olympus.co.uk

5

TREND SURFING

Tryvertising

The retail trend of offering free samples in exchange for comments is sweeping the globe. Japan started it all with coffeeshop LCafe in Tokyo's Shibuya district. The Spanish Esloúltimo chain offers a variety of food, cosmetic and technological goods in exchange for a simple comment on the product.

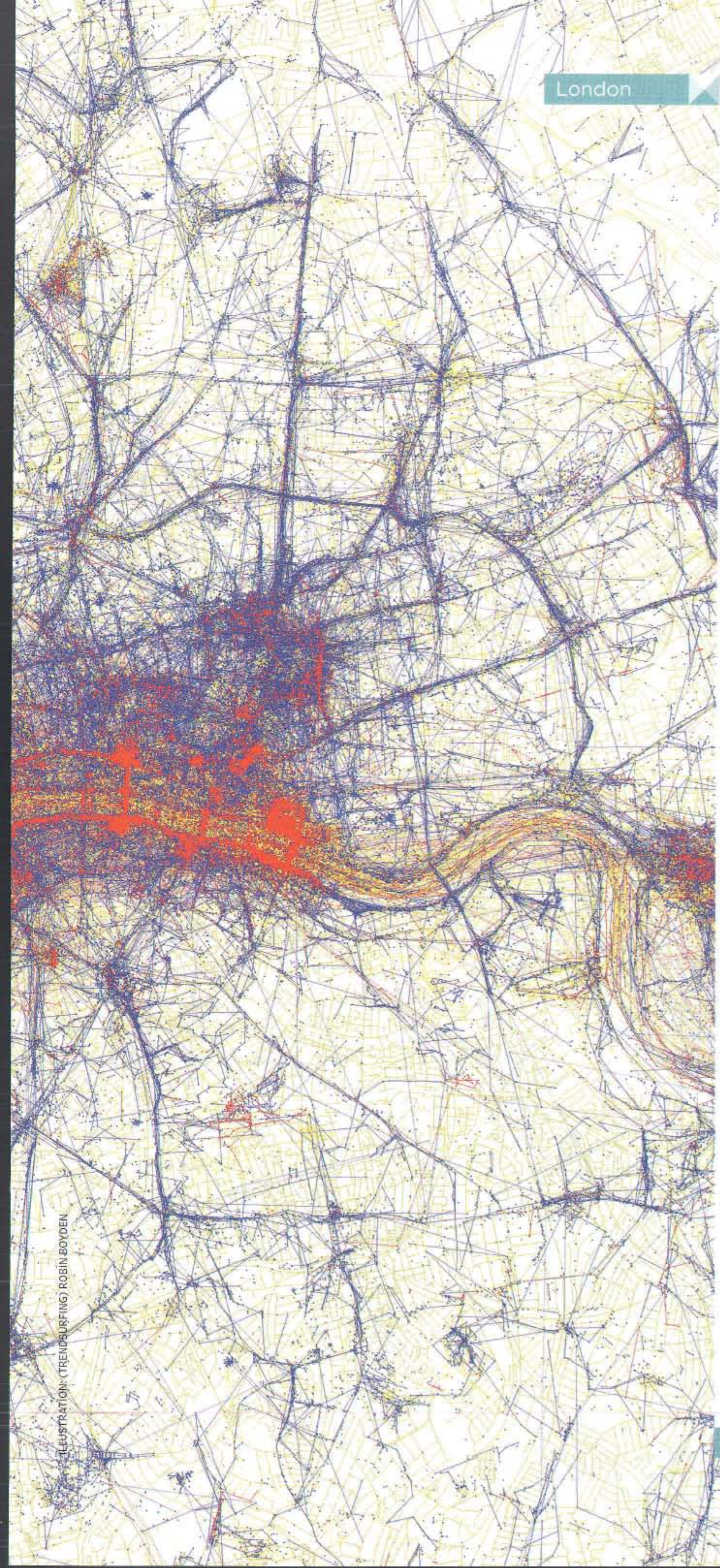
Goat power

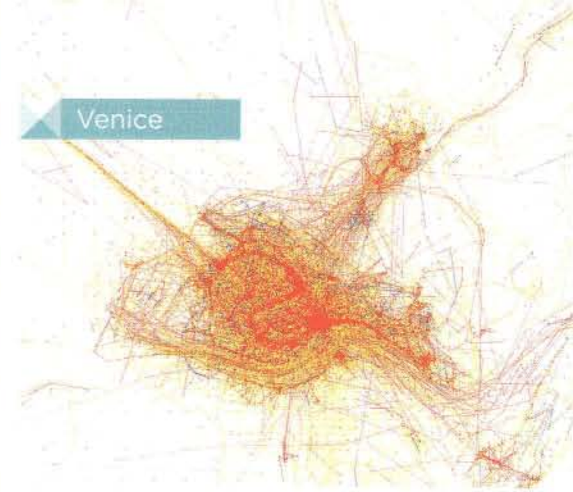
A goat is now an eco-friendly essential as gardeners swap gas-guzzling mowers for grass-nibbling livestock. Google has hired 200 goats from rental firm California Grazing to trim the fields at its HQ, and the Vanderbilt Mansion in New York is also using them. Rent-a-Goat.com offers them from $200 (£130) per day.

Analogue apps

Perfection is a thing of the past. iZotope Vinyl recording software adds the sound of dust on a record and other analogue touches to a digital track. The *Hipstamatic* iPhone app filters a perfect photo so it looks as if it were taken using expired-date film in a plastic toy camera with a faulty lens.

Miriam Rayman





LONDON
Tourist photos: 469,796
Local photos: 1,070,144
Unknown: 846,120

Unsurprisingly, the capital's tourists crowd Westminster and Piccadilly; north and east London are a cooler blue. Fischer expects an explosion of red around the Olympic site in 2012.

VENICE
Tourist photos: 145,138
Local photos: 26,209
Unknown: 247,503

The city's *centro storico* receives nearly as many tourists a day (50,000) as it has permanent residents (60,000), and it shows: the waters of the Grand Canal are turned bright red.

Crowd busting

The geotags in Flickr reveal a city's tourist hot-spots

Depending on where you're from, the red on these maps shows a welcome or a warning. Californian computer programmer Eric Fischer originally created the Geotaggers' World Atlas, taking geotagged photos from Flickr and plotting them on maps. Commenters interpreted the atlas as a guide to avoiding tourists. So Fischer wondered whether there was a way to differentiate pictures taken by tourists and those taken by locals. Over a few weekends in May 2010, he wrote a program to analyse the photos, dating from May 11, 2004, to May 12, 2010, according to when they were taken; if a user took pictures in the same city for more than a month, they were classified as a local. Residents' photos are shown as blue points, tourists' as red. And yellow? "I didn't really know what to do with those." To see all 121 maps, go to *bit.ly/aDVic9* **TC**

ILLUSTRATION: (TRENDSURFING) ROBIN BOYDEN

She grows bones

Meet Imperial College's limb-regeneration expert

"Consider soldiers back from Afghanistan without limbs," says Molly Stevens. "I do geeky, hardcore science, but my aim is helping patients." The 36-year-old professor of biomaterials and regenerative medicine is based at the London Centre for Nanotechnology, Imperial College, London, where she heads a team of surgeons, chemists, biologists and physicists. They create biomaterials that enable the body to regenerate its own bones. One of her new products, a compound containing strontium, has been approved by the EU for use in humans. Implanted into living bone, it cues cells to fill in the damage. "We are also close to creating a finger joint," she says. "Regenerative medicine is really evolving." **Aarathi Prasad**

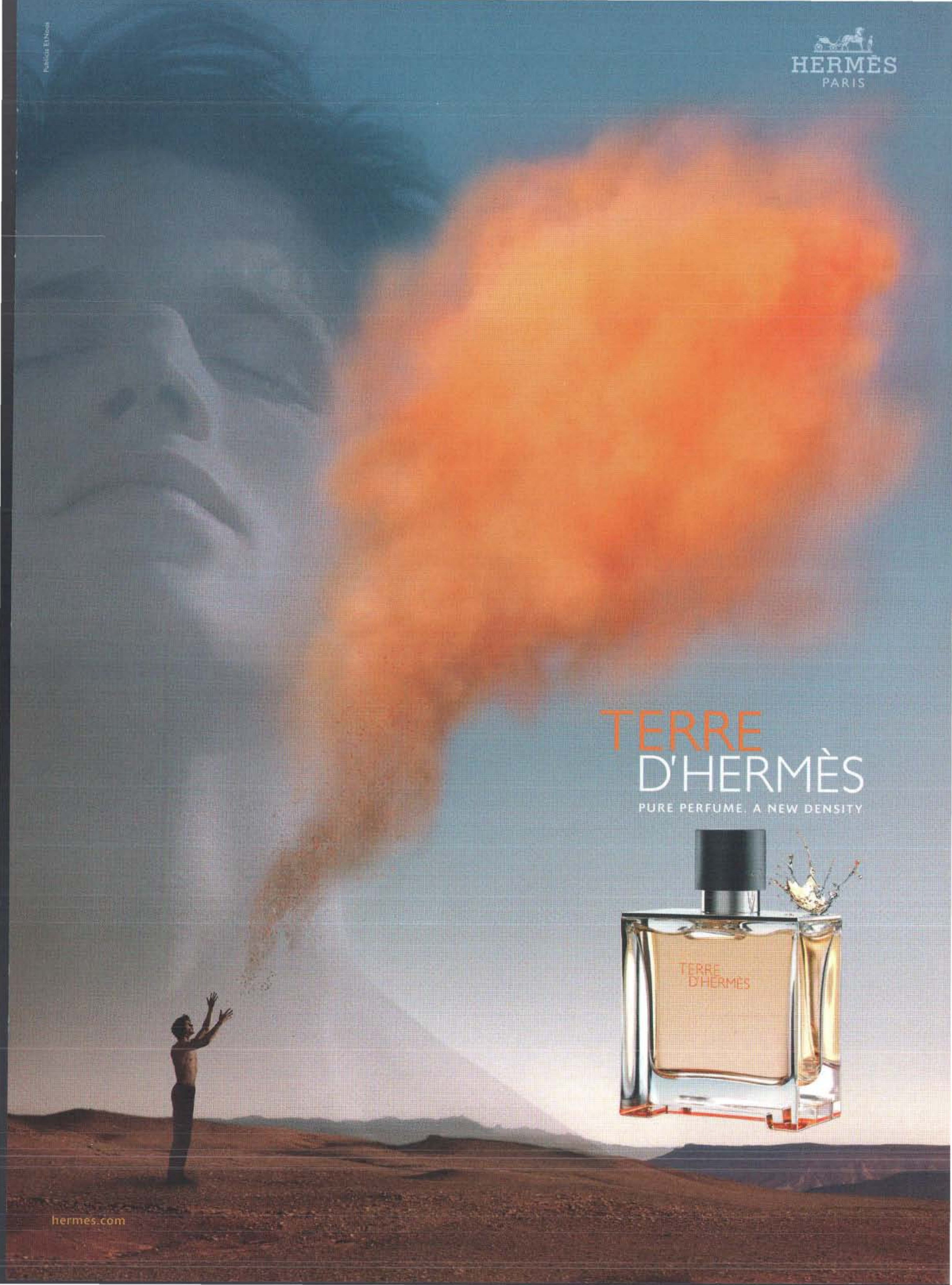
Name: MOLLY STEVENS
Occupation: BIOMATERIALS PROFESSOR
Location: LONDON

PHOTOGRAPHY: LEON CSERNOHLAVEK

THE SMART ENERGY CYCLE

MIT's SENSEable City Lab has, quite literally, reinvented the wheel. The Copenhagen Wheel captures and reuses the kinetic energy lost when braking, to give you an extra push through your pedal torque. It houses sensors that collect data on air quality, temperature and road conditions and, because it recognises you through your smartphone's Bluetooth connection, it can supply this information to help you plan healthier routes or devise a new fitness routine. Plus, if your bike gets stolen, the security system sends you an SOS text message with its location. The aim is to have the wheel available for sale by June next year, for approximately $600 (£385). **Jennifer Lucy Allan**

Voice of America (the official external radio and television broadcasting service of the US government)...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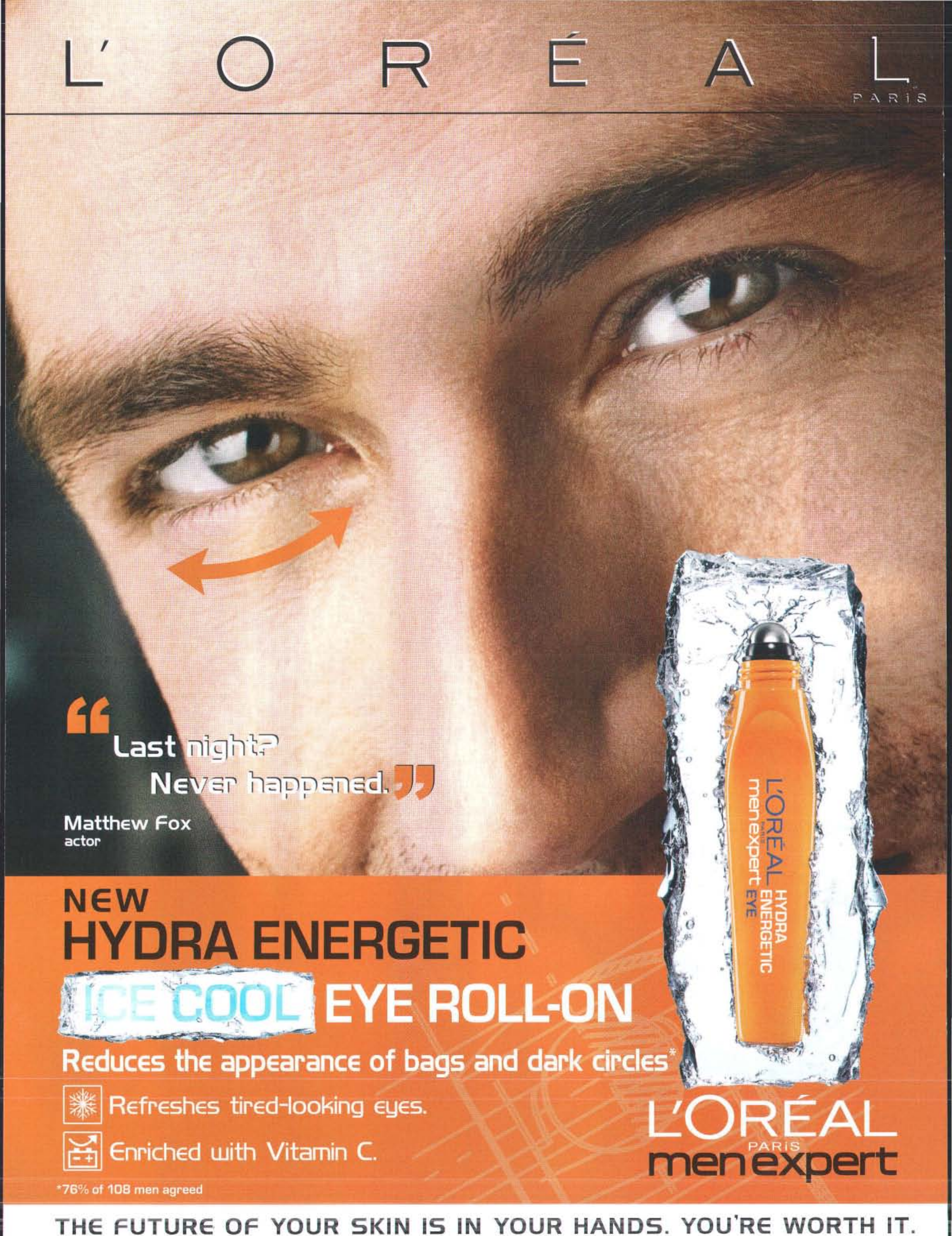

L'ORÉAL
PARIS

"Last night?
Never happened."

Matthew Fox
actor

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*76% of 108 men agreed

L'ORÉAL
PARIS
men expert

THE FUTURE OF YOUR SKIN IS IN YOUR HANDS. YOU'RE WORTH IT.

Sweden's data-driven skidpan

The Arctic winter is the perfect setting for an extreme-motoring test-bed

In the tiny Swedish town of Arvidsjaur, just 100km south of the Arctic Circle, temperatures can drop to minus 40°C in winter, and the Sun barely rises.

This makes it the perfect location for the Continental Corporation's Proving Grounds, one of the car industry's biggest and most challenging research-and-development playgrounds. Every autumn, automotive engineers from around the world arrive at the tyre company's facilities for extensive testing of their latest prototypes. (Although they all eat and drink in the same bars and cafés, industry protocol is that no one talks about their products.)

The Arvidsjaur facility comprises two 500-metre by 30-metre snow tracks, a extreme-snow-handling track, an uphill track and an ice track. Cars are tested in conditions from deep snow and polished ice to "split-μ" surfaces, where one side of the car drives (and brakes) on a low-friction material such as ice and the other on a high-friction one such as asphalt.

According to the testers, a trip to Arvidsjaur is great fun but the work done here also saves lives. That is, unless you hit a reindeer: Swedish law dictates that you must put the animal out of its misery. **Jason Barlow**

ILLUSTRATION: MITCH BLUNT

BULLETPROOF CUSTARD

The next generation of bulletproof vests has a lot in common with custard. Scientists from BAE Systems' Advanced Technology Centre in Filton, just outside Bristol, have developed a "liquid" body armour made of shear-thickening fluids which solidify on impact, absorbing shock – just as custard becomes more resistant the faster you stir it. Sandwiched between Kevlar sheets, the liquid polymer disperses impact more evenly than traditional armour, which means quicker recovery times.

The vest is also lighter, using ten sheets of Kevlar rather than the usual 30. But don't go charging in just yet. Researchers are currently conducting high-velocity impact tests and, according to Stewart Penney from BAE, "getting shot will still bloody hurt". **TC**

< The unknown story (refers to the book, *Mao: The Unknown Story*)... >

Pioneer

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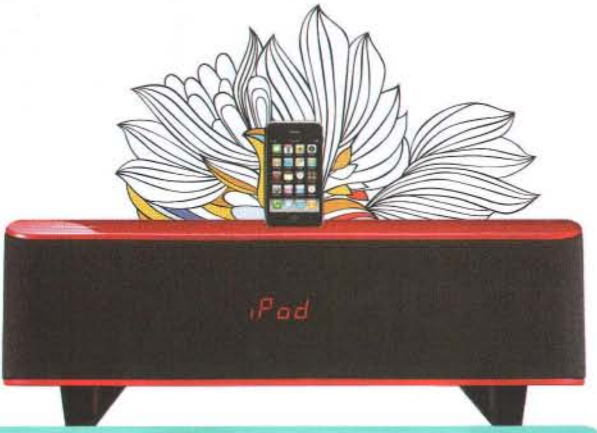
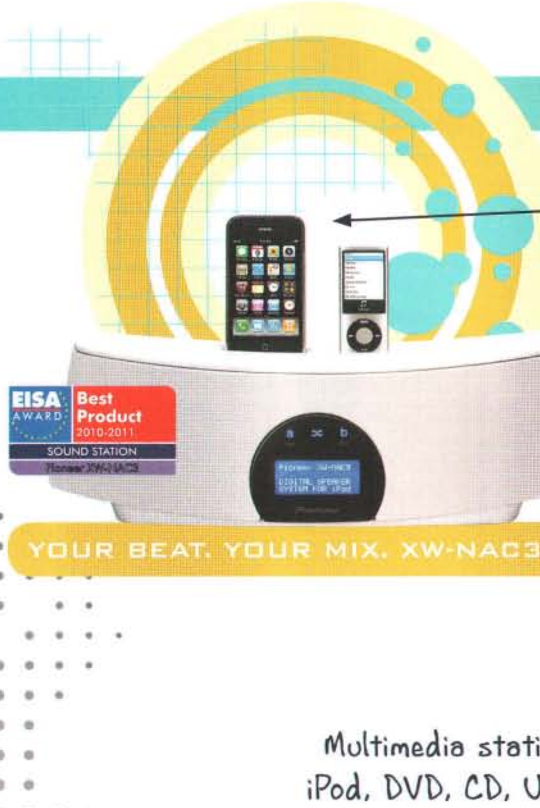
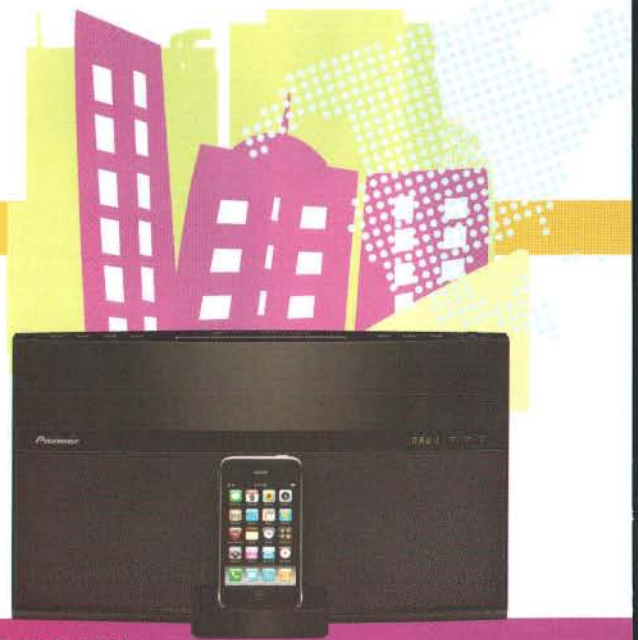


YOUR MUSIC. YOUR PASSION. XW-NAS5



Double shuffle between two
connected units simultaneously

YOUR BEAT. YOUR MIX. XW-NAC3



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% THE WIRED INDEX

87%

Proportion of those who received venture capital during the first half of 2010 in the US who are white, based on a study of 165 Seed VC and Series A investments

92%

Proportion of those who are male

3.54M KM/H

Speed of the eruption of a solar flare on August 1, 2010

250

Number of swimming pools without planning permission found in Riverhead, New York, August 2010 via Google Earth. Total of fines on the owners: $75,000

854,000

Number of people in the US with "top-secret" security clearance, across 1,931 private firms and 45 government bodies

$3.2m

Reported budget of *3D Sex and Zen: Extreme Ecstasy*, a 3D porn film being produced in Hong Kong

16%

Proportion of "symptoms" of chemical contamination caused by mass hysteria based on a 2010 study of 280 leaks
For sources, see page 162

ILLUSTRATION: MATTHEW TAYLOR

It's not the winning...

Six ways to get rich quick, or save the world trying

X Prizes and similar competitions are offering big-dollar bounties for solutions to the toughest humanitarian and scientific problems. WIRED helps you plot how to make your benevolent millions. **Jennifer Lucy Allan**

GOOGLE LUNAR X PRIZE **Started:** September 2007 **Prize:** $30 million	This is a race to land a robot on the Moon, and get it to travel 500 metres and transmit high-resolution video back home. US team Astrobotic Technology has set a 2012 launch date. **Effect on humanity rating:** 4/10
MILLENNIUM PRIZE PROBLEMS **Started:** May 2000 **Prize:** $1 million	Crack one of seven "unsolvable" maths problems to win $1m. Reclusive Russian Grigori Perelman won the prize in March for solving the century-old Poincaré conjecture – but he refused the money. **Effect on humanity rating:** 2/10
INDEX:AWARD **Started:** 2005 **Prize:** €500,000 shared between five	Do you have a "Design to Improve Life"? This award, sponsored by the Danish government, seeks design with a positive impact. Kiva and Philips's Chulha stove are among past winners. **Effect on humanity rating:** 9/10
ARCHON X PRIZE FOR GENOMICS **Started:** October 2006 **Prize:** $10 million	The winner will sequence 100 human genomes in ten days for less than $10,000 a genome. The best so far is one genome, in four weeks, for $48,000. Still, the Human Genome Project cost $3 billion. **Effect on humanity rating:** 8/10
LOEBNER GOLD PRIZE MEDAL **Started:** October 2006 **Prize:** $100,000	Every year inventor Hugh Loebner doles out $2,000 to the most convincing chatterbot. A prize of $100,000 is promised to the first program to pass the Turing test. **Effect on humanity rating:** 1/10
WENDY SCHMIDT OIL CLEANUP X CHALLENGE **Started:** August 2010 **Prize:** $1.4 million	This should help oil executives get their lives back faster: the Cleanup Challenge is looking for ways to "speed the pace of cleaning up seawater surface oil" from spills like Deepwater Horizon. **Effect on humanity rating:** 7/10

Scrubbing up on the sports field

How playing hockey for Team GB helps surgeon Abi Walker keep a steady hand

When Abi Walker isn't playing hockey as a goalie for Great Britain, she has a scalpel in her hands. "I have broken five or six fingers playing hockey – but you could slip in surgery and probably cut one off," says the 28-year-old Glaswegian. Besides working three days a week as a plastic surgeon at St George's Hospital in Tooting, south London, Walker also spends two days training with Team GB at Bisham Abbey National Sports Centre in Buckinghamshire, in preparation for the 2012 Olympics. At weekends she plays club hockey for Canterbury.

"There are massive parallels between sport and medicine. Both are very much team games. Both need self-discipline and self-motivation," says Walker. She finds hockey, which she has been playing since primary school, leads to introspection whereas medicine gives her a sense of the bigger picture. "You can't give everything to medicine. That's a quick way to alcoholism and drug addiction. So I also do hockey." **Christine Ottery**

Name: ABI WALKER
Job: SURGEON AND FIELD-HOCKEY PLAYER FOR TEAM GB
Location: RICHMOND, SURREY

PHOTOGRAPHY: RICHARD CANNON

WIRED	TIRED	EXPIRED
Real-time virals	Personalised text-ads	Banner ads
Anti-censorship steganography	Tor	CGI proxy
Diaspora	Facebook	MySpace
Neoinformationalism	Neoliberalism	Neo
PeerIndex	Technorati	Daypop

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L'EAU D'ISSEY POUR HOMME

ISSEY MIYAKE

Copying and pasting an old master

Three 400-year-old oil paintings have been legally and lovingly ripped off

It's almost impossible to recreate a Caravaggio but conservationists in Italy have done it. The Municipality of Caravaggio has commissioned Factum Arte, the Madrid- and London-based restorers, to produce facsimiles of three paintings by the Italian master in the Church of San Luigi dei Francesi in Rome – *The Calling of St Matthew*, *The Martyrdom of St Matthew* and *St Matthew and The Angel (see right for details)*. The facsimiles will form part of a new research centre where scholars and tourists will be able to scrutinise the copies up close. "In the church of San Luigi, you can see them only from one angle, from outside the chapel looking in," says Adam Lowe, director and founder of Factum Arte. "In the research centre you'll be able to see them completely differently. It's about how technology is transforming our understanding of what these objects are." **Michael Dumiak**

HOW TO HACK A CARAVAGGIO

RECORD A 35mm digital camera mounted on vertical linear guide rails takes 5cm² images (about 3,500 per painting) from a distance of 15cm.

COMPILE The hi-res images are stitched together like a big quilt. Each file is about 6GB, and Factum spent a month shooting the chapel.

SET The facsimiles are mounted on gesso-coated canvas. Epoxy resin and fibreglass tape on the back of the canvas strengthen joins.

PLACE The pieces of the facsimile are joined to make a seamless image. Any flaws are retouched out, and surface sheen is reduced.

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THE GAME IS JUST THE START...
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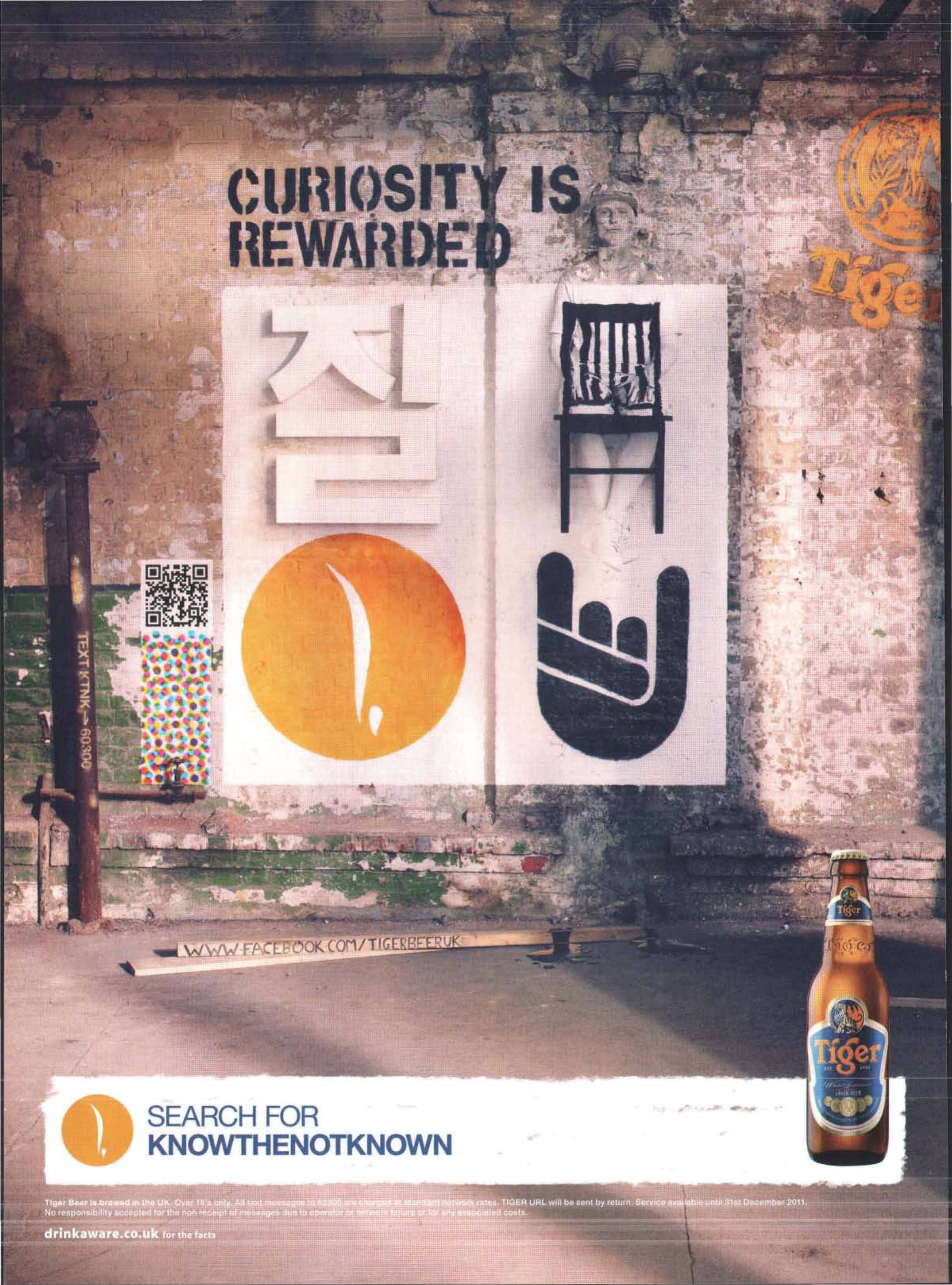


Tiger Beer is brewed in the UK. Over 18's only. All text messages to 60300 are charged at standard network rates. TIGER URL will be sent by return. Service available until 31st December 2011. No responsibility accepted for the non receipt of messages due to operator or network failure or for any associated costs.

drinkaware.co.uk for the facts

THE APPS THAT BENEFIT SOCIETY

The Apps For Good project, launched in Tulse Hill, south London, last April, teaches young, disadvantaged people how to make apps. It is based on the success of the Centre for Digital Inclusion (a Brazilian NGO). WIRED rounds up its first batch.

Stop and Search

Tapping into community concerns about the abuse of stop-and-search by police forces, the *Stop and Search* app wraps up a guide of your rights along with a tool to grade and geotag your encounter. It will also help you make a complaint if you feel you were mistreated.

StudentVoice

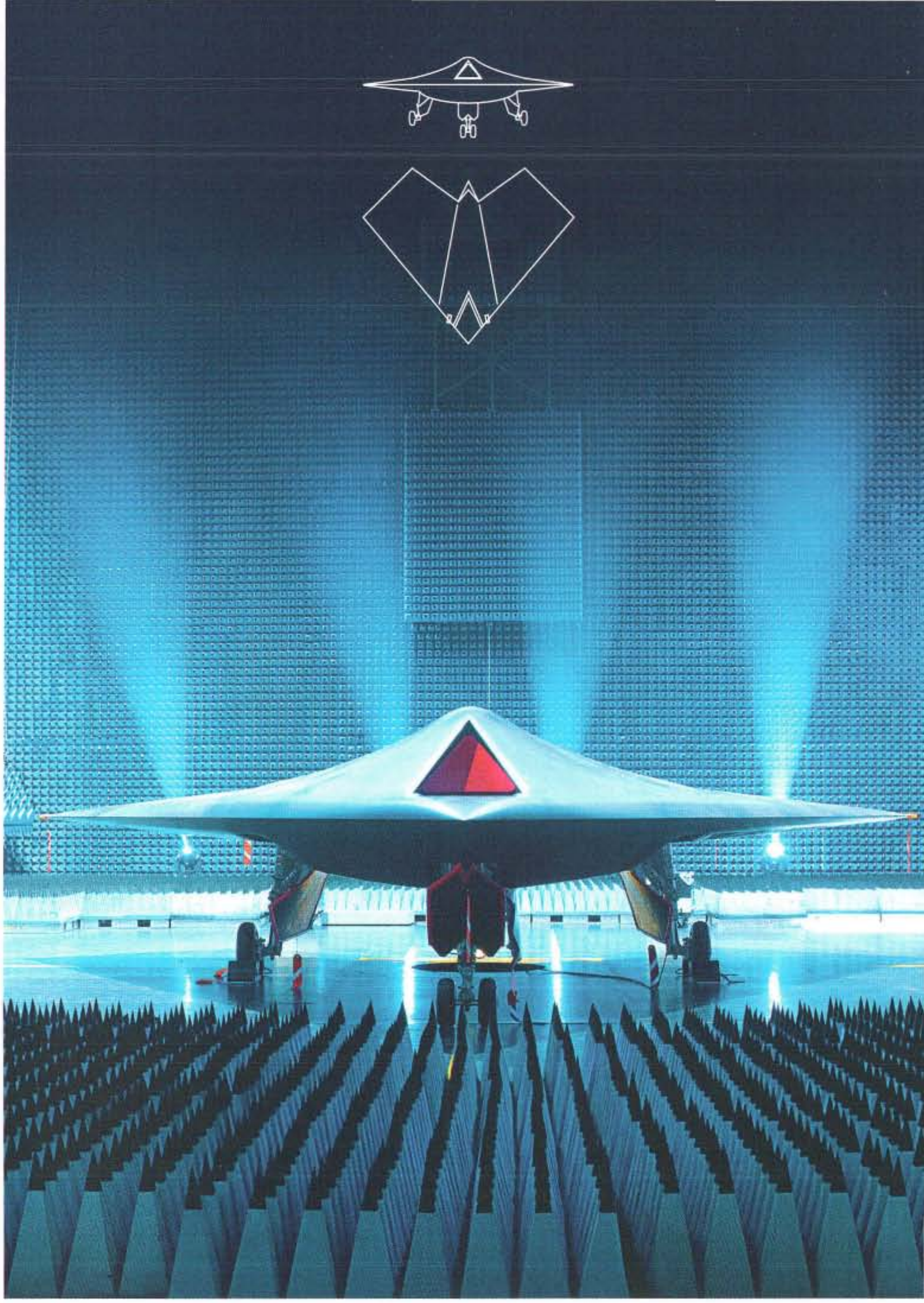
"Going out is a huge part of being a student, but most of the information comes from the college, not from students," says mentor Antony Marcano. *StudentVoice* integrates with maps, search tools and review sites such as Qype to identify hotspots that your square lecturers won't know.

StudioPhly

The app searches a database of recording studios, then meshes with Google Maps to help musicians find the right place to get the right sound. "We now want people to get a discount for booking studios they found with *StudioPhly*," says mentor Eric Donovan.

Daniel Nye Griffiths

ILLUSTRATION: GARY NEILL



Deadly by design

BAE Systems' new unmanned aircraft boasts killer looks – with spying and combat capabilities to match

Unmanned aerial vehicles (UAVs) may be the future of airborne warfare, but they tend to resemble winged spermatozoa – until now. The Taranis is a prototype stealth drone developed by BAE Systems in Warton, Lancashire. It can penetrate deep into hostile territory to gather intelligence or strike targets at long range (a continent away) with its two weapons bays. Plus, its delta-shaped profile makes it hard to detect.

"Taranis has been designed to utilise the most advanced means possible of achieving low observability," explains Steve Worsnip, programme director of Combat and Strategic Unmanned Aircraft Systems at BAE. "This includes the shape, design and finish of the exterior." Worsnip is tight-lipped on details, but the demonstration model has an approximate wingspan of ten metres, is four metres high and weighs eight tonnes, making it one of the world's largest UAVs. The jet took three years, a million worker-hours and £142.5 million to build. Flight trials begin in 2011. **TC**

< Chinese Central Propaganda Department... >

DAN ARIELY

'People fail to think creatively when it comes to their usernames and passwords'

Opportunities emerge from odd situations. Last June, tense Israeli-Turkish relations brought on a cyber attack from Turkey, and major Israeli sites were hacked, including Pizza Hut's. Roughly two per cent of the pilfered Israeli details were published on Turkish forums. Naturally, these spreadsheets, containing usernames, passwords and addresses, became widespread and one of the people who got hold of them has a job title no less defamed than a hacker's – an economist. That's me.

After some basic analysis, I was left with some interesting insights that reveal the extent to which people fail to think creatively or incorporate even a touch of randomness in their username and password selection.

I focused on a spreadsheet containing the details of 31,588 users of a listings website, which I chose because the site was particularly lenient when it came to registering. One-digit password? Not a problem. It isn't the best security policy, but is valuable to our analysis as it shows what people will do when they are unconstrained.

Of the 31,588 registered users, 15,820 (slightly over 50 per cent) carelessly used their email address as their username. Furthermore, 675 people (more than two per cent) picked their phone number – both of which indicate a lack of creativity. However, the really interesting discovery was in their password selections. The most common was "123456" (584 users), with "1234" as the runner-up (569) and "12345" coming in third (388). All in all, 1,786 passwords (one in 18, or 5.65 per cent) comprised consecutive increasing numerals.

Roughly one in 40 chose a password identical to their username and 417 users (1.32 per cent) opted for identical digits (eg, "1111"). Keyboard patterns were ubiquitous, horizontal in particular: along with the top of the 1,786 "123..." passwords mentioned above, 123 began with "qwe" (including 25 instances of "qwerty"), 41 with "asd", and 31 with "zxc". Forty-eight began with "abc" (eg, "abcdef", "abc123", etc). And, finally, 69 passwords had variants on the word "password", with no fewer than 29 exact matches.

Using this information, mischief-makers hacked into thousands of email and online accounts – a task made easier by the high percentage of people who use the same password for different sites. This refutes the argument that people carelessly enter easy passwords because they don't care about that a account.

I also noticed that roughly 200 people chose the word "pizza". This made me think that selection is influenced by cognitive availability. I went back to the data and found that 89 users had the website name as part of their password. Others had nouns like "coffee" and brands like "nokia", "acer", "cocacola", all of which can be attributed to physical objects in the user's sightline. Add this to the 2,000-or-so patterned passwords mentioned earlier (visual availability on the keyboard), and in my view you get a plausible explanation.

So what can account for this behaviour? Let me suggest a few explanations by using "John", an imaginary, typical internet user. When John first sets up an account, he will get a blank profile on completing his registration. Since his profile will contain no information, the cost he will pay (in terms of lost information, contacts, time etc) in the event of a hacker taking over his account is close to zero. Hence, he is reluctant to conjure up a unique password.

The problem exists when his private Facebook page is populated by flirtatious "Janes". Then, a more secure password is of value, but he irrationally sticks to the original. He could be a procrastinator or forgetful, or it could be due to a sunk-cost bias – in his mind, he spent time setting up a password, and so refrains from doing so again. As time passes, the incentive to change it is greater – but tell that to John.

When I first got hold of the files, I didn't expect to find them interesting, but now I see value in studying password choices. The analysis suggests a decision-making problem where both behavioural and cognitive processes and biases come into play. Since it's a one-shot game, and the result confidential (unless security is breached), the setting is simplified and the observed behaviour is of research value. It's a natural experiment; it's just unfortunate how the data was obtained. Still, if you have any more theories to explain password selection, please feel free share them. Don't worry, no registration is required...

ILLUSTRATION: MATTHEW GREEN

MICROBIOGRAPHY

Dan Ariely is the James B Duke professor of behavioural economics at Duke University, North Carolina, and the author of *The Upside of Irrationality* (HarperCollins)

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LAB NOTES #3

Monkey see, monkey do

Mimicking verbal and nonverbal behaviours of others may make you more likeable, sexually attractive, wealthier and even a better person.

A recent study from the *British Journal of Psychology* concluded that "both mimickers and mimickees reported more feelings of having bonded with each other and rated the interaction as smoother".[1]

This certainly applies to romance. A study of speed-dating sessions, at the University of South Brittany, France, showed that "men evaluated the dating interaction more positively when the woman mimicked them, and that mimicry was associated with a higher evaluation score of the relation and the sexual attractiveness of the woman".[2]

Mimicry can also bring financial profits. A Dutch study in the *Journal of Experimental Social Psychology* showed that waiters could easily increase their tips by "merely repeating a customer's order back to them".[3]

But life's not all about money and manipulating people: copycatting can also help you be a better person. A study in the *European Journal of Social Psychology* suggested that "mimicry created an affective empathic mindset, which activated prosocial behaviours directed toward others".[4]

But can that be a liability, too? Definitely. Creating a bond with the wrong person might lead you astray. A study by Leiden University, Holland, showed "nonmimickers were more accurate than mimickers in their estimations of targets' truthfulness".[5]

So mimicry can be a powerful tool, but be careful who and what you imitate. **Eric Barker**

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PHOTOGRAPHY: CHRIS MUELLER. ILLUSTRATION: JOE MCLAREN

Toxic avenger

Meet the lawyer taking on the giants of the American food industry

As WIRED went to press, the US was in the grip of a salmonella scare, which means that Bill Marler (*above*) is likely to be getting busy. Marler has been the leading US food-contamination lawsuit attorney since 1993, when he won $15.6 million for a girl who nearly died after contracting *E. coli* at US burger chain Jack In The Box. He is also an activist and blogger, campaigning for greater food-industry safety. Nikhil Swaminathan

Is the US's food safer since the Jack In The Box *E. coli* outbreak in 1993?

We didn't see any *E. coli* – related to hamburgers, at least – from 2003 to 2006. Of course, that's when we started to see a lot of *E. coli* O157:H7 in leafy greens... There was never a downturn – it just became a different product line. I don't agree with [food writer] Michael Pollan and [author of *Fast Food Nation*] Eric Schlosser that we can feed the US population from farmers' markets alone. But if we simplify our food supply – regionalise it a bit, make it less complex – the chances of having a significant outbreak would be reduced.

You're campaigning to get more *E. coli* variants labelled as contaminants.

Six other strains of *E. coli* still aren't counted by the US Department of Agriculture (USDA) as contaminants. There's no logical reason why *E. coli* O157:H7 should be and these aren't. The only explanation I've gotten from the USDA's Food Safety and Inspection Service has been, "Well, we've never found it in hamburgers." But I've found it in hamburgers.

You just addressed the annual meeting of the US National Meat Association. Was that a tough audience?

It was a packed house. And I did acknowledge the progress that they've made, but I also told them that they still have work to do. I said, "You can do the right thing because you don't want your product to kill someone's kid. Or you can do it because you're afraid I'll come after you and leave you bankrupt and penniless. I don't care which it is."

RUSSELL DAVIES

'Extending our lives is one thing – keeping our knees going all that time is another'

My dad has come out top in civilisation, and won at history. He is in his seventies now and his and my mum's generation have lived some of the best lives there'll ever be. Free education and healthcare, no major wars, lots of travel, lots of high-quality costume drama. For ordinary people, they've reached the tippity-top. Dad worked for one company all his life doing a job he enjoyed. He retired early with the final-salary pension that nationalised industries gave back then.

Since then he's climbed every Munro in Scotland, visited every steam railway in the country and he and my mum have travelled to every corner of the world – coming to air travel when it got cheap and easy, before it became guilt-inducing and rubbish. They've paid off the mortgage on a modest home in the east Midlands, they see their grandchildren a lot, they love Classic FM. They worked hard to live this way; now they're enjoying it. It's what most British people, for a lot of their history, would have regarded as a well-lived life – the life you're supposed to pursue, the life this country has structured itself to promote. And while many people aren't as lucky as my parents, huge numbers of them are – enough that they're a potent, though disregarded, force.

In fact, when you look outside of the tech bubbles and the youth media, you realise how much the older generation is dominating huge swathes of our culture and economy. Visit the Peak District and its environs and you can see non-urban economies adjusting rapidly to pensioner economics. The smarter towns are full of antique and knick-knack shops, next to cafés that'll do you a panini and a cappuccino, while others substitute these with charity shops and mobility centres. And, everywhere, garden centres are the thriving hubs of economic activity, because this is mostly a post-consumption cohort. They buy fleeces, gifts for the family and lots and lots for the back yard. Garden centres have all that nailed. It's pensioners, not media addicts with their downloads and DVD box sets, who are pioneering a genuine "experience economy". It's just that the experiences they cherish aren't all about space tourism or immersive theatre, they're about the National Trust, model villages and the relentless pursuit of frothy coffee.

These are the leisured lives the futurists promised us; relaxation, travel and mind-broadening. They even predicted the love of man-made fibres. Don't we all have that hazy watercolour illustration somewhere in our heads? Standing, with your arm around a loved one, on the deck of a gleaming cruiser (space or ocean, it's not clear), there are stars glittering above, or maybe a rainbow or a sunset, and dolphins are gambolling below (I guess it's an ocean cruiser then, unless they're space dolphins)...

Well, forget it. It's not going to happen.

Because for all that the garden-centre moguls hope otherwise, we're not going to get those lives. Instead we're facing working lives far, far longer than they ever imagined. Medical and health technologies are going to nudge, prod and support us well into our hundreds, and economic and demographic forces are going to insist we keep working for most of that span. (Perhaps that's why so many of us are reluctant to actually get started?) Many of you reading this can anticipate working lives of more than 100 years. Which, on the upside, makes any notion of career-planning seem ridiculous – the wisest response is most probably to do whatever is fun and remunerative at the time. Entire industries are arriving and then disappearing within the span of a single working lifetime – and this will not get any better. The idea of working your way up the ladder seems faintly ridiculous when said ladder is being set on fire from below, dismantled from above and no longer has anything to lean against.

My friend Matt Jones has posted some of his thoughts about this on his blog (magicalnihilism.com): "I'm going to be 40 soon. I find myself thinking about how to become a sustainable/resilient 50-year-old... 50 might be halfway through... it might only be a third of the way through my life. I've been very lucky for the past 20 years. What the hell am I going to do with all that time? How will I be able to pay my way? How do I stay involved and useful?" These are good questions, and ones I couldn't begin to answer, except that I'm sure older life is not going to be about careers; it's going to be about learning to learn and being ready and willing to start all over again. And it's going to be work that involves a lot of sitting down. Because extending our lives is one thing, keeping our knees going all that time is another.

ILLUSTRATION: ADRIAN JOHNSON

MICROBIOGRAPHY

Russell M Davies previously worked in advertising, launching Microsoft Office and Explorer. He organises the London Interesting conferences and blogs at russelldavies.com

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**Sources: Arab Media Outlook 2010. Media on the Move 2009. A.T. Kearney.*

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When bad goes good

Hackers who moved from black hat to white hat offer some tips. **By Leila Johnston**

NAME: ADRIAN LAMO
Age: 29
Nationality: American

Lamo hacked *The New York Times*'s systems in 2002, in order to use a LexisNexis (newspaper archive) account. In 2003 he pleaded guilty to crimes against Microsoft, LexisNexis and *The New York Times*. He was sentenced to six months' detention at his parents' home, two years' probation and a $65,000 fine. He is now a threat analyst and journalist. In June 2010 he was involved in the arrest of US soldier Bradley Manning, who Lamo alleges confessed to him that he had leaked the "Collateral Murder" video of a July 2007 US Baghdad air strike to WikiLeaks.

What are the biggest online-security threats to businesses or individuals?
"By seeing hackers as a threat, with no shades of grey, industry and government diminish network security and turn away one of the deepest talent pools available to them. Not all conduct is equal. A criminal spammer is very different from a benign intruder who broke the law, but the government just doesn't get it."

NAME: ROBERT SCHIFREEN
Age: 46
Nationality: British

Robert Schifreen and Stephen Gold got into British Telecom's Prestel service in 1985 with system-manager passwords. They were later arrested and Schifreen was found guilty on five charges and fined £750; Gold was found guilty on four, and fined £600. The men appealed and were acquitted. In 1988 the House of Lords agreed with the acquittal, a judgment that led to the Computer Misuse Act 1990. Schifreen now works at the University of Brighton and runs an IT consultancy.

What are the biggest online-security threats to businesses or individuals?
"The same as they were 25 years ago: ignorance and complacency, both on the part of software developers (especially people doing web development who don't have a clue about security), and end users who blindly trust every email that arrives in their inbox. The answer is to invest in training and education, not to keep buying more security products."

NAME: GARRY PEJSKI
Age: 31
Nationality: Canadian

In 2004, Pejski took a job leading a programming team in Vancouver. The team was told to build invasive software and, initially believing it to be legal, Pejski helped to create a program that tricked users into installing spyware. Pejski's bosses were also accused of affiliate hijacking (picking up other users' pay-per-clicks) and a pay-per-install scam. The company was never prosecuted but Pejski left after seven months and has been working at Matrikon, an industrial-intelligence company, since 2006.

What are the biggest online-security threats to businesses or individuals?
"The biggest security problem is that machines run every application by default. If anyone on the internet can trick your computer into running a malicious program even once, they can control your machine, and you'll never know it's happened. You'll be able to use your computer, but they'll be collecting passwords, credit cards, everything."

NAME: MARK ABENE ("PHIBER OPTIK")
Age: 38
Nationality: American

Abene was associated with both the Legion of Doom and Masters of Deception hacker groups during the 80s. In December 1991, he was arrested with four other Masters of Deception and charged on 11 counts. He pleaded guilty to conspiracy and unauthorised access to computers of federal interest, earning 12 months' imprisonment, three years' probation and 600 hours' community service. Since April 2009, Abene has been running network-security firm Tracevector in New York.

What are the biggest online-security threats to businesses or individuals?
"The chief threat to business is an insecurely coded website. While it's good to have an infosec firm periodically perform a secure-code review, this is reactive rather than proactive. IT managers should push for awareness training. The problems of insecure coding are well known and it wouldn't be hard to compile material for in-house training."

ILLUSTRATION: DAVE PLUNKERT

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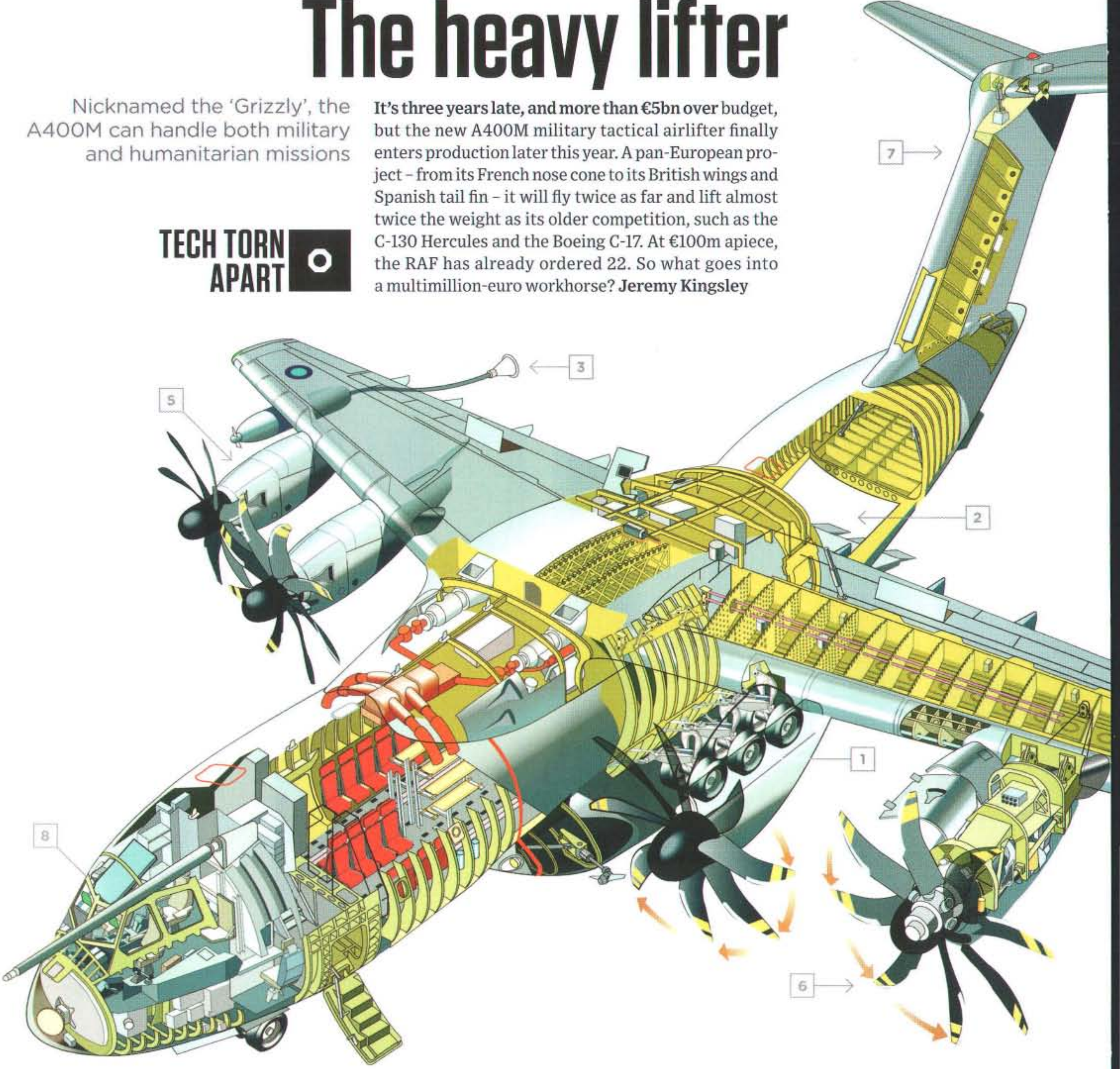
The heavy lifter

Nicknamed the 'Grizzly', the A400M can handle both military and humanitarian missions

TECH TORN APART

It's three years late, and more than €5bn over budget, but the new A400M military tactical airlifter finally enters production later this year. A pan-European project – from its French nose cone to its British wings and Spanish tail fin – it will fly twice as far and lift almost twice the weight as its older competition, such as the C-130 Hercules and the Boeing C-17. At €100m apiece, the RAF has already ordered 22. So what goes into a multimillion-euro workhorse? **Jeremy Kingsley**



HOW IT WORKS

Counter-rotating propellers make for a symmetrical airflow over the wing that gives greater lift and lessens torque, allowing greater manoeuvrability and a lighter wing and rudder. Combined with its 30 per cent build of carbon-fibre composites, the A400M weighs 70 tonnes when empty – 55 tonnes lighter than the Boeing C-17. That means the A400M can carry a 20-tonne load 6,400km before refuelling.

1 LANDING GEAR
The 12-wheel landing gear, with hydraulic legs and low-pressure tyres, can support the 120 tonnes of fully packed airlifter on makeshift runways. The legs can also "kneel" to aid loading.

2 CARGO HOLD
The hold can fit up to 37 tonnes of cargo: that equals two Apache AH-64 helicopters, or 116 paratroopers, or three ambulances, or 66 stretchers and 25 seated medical staff.

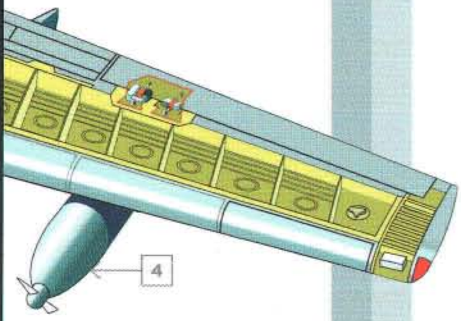
3 AIR-TO-AIR REFUELLING PODS
The A400M can be refuelled midair, as well as doubling as a tanker for other aircraft. The system, with pods at each wing, can pump fuel at up to 1,200kg/min.

4 EMERGENCY POWER GENERATION
The aircraft's Ram Air Turbine (RAT), a small turbine under the wing, uses the airstream provided by the plane's speed to generate electricity.

5 EUROPROP TP400-D6 ENGINES
The four TP400-D6 engines are the most powerful in the world yet are still lighter than jet engines. They generate 11,000hp, giving a 780kph cruising speed.

6 COUNTER-ROTARY PROPELLER ROTATION
Each engine bears eight polyurethane-coated propeller blades, measuring 5.3m tip to tip.

7 TAIL FIN
The counter-rotating engine setup allows for a greatly reduced tail fin. The "T-tail" shape improves efficiency and permits easy access to the cargo hold.



8 FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC) SOFTWARE
Two fly-by-wire systems ensure greater handling but also mean highly complex software.

BOOKS ILLUSTRATION: HARRY CAMPBELL. PHOTOGRAPHY: IAN ALLEN

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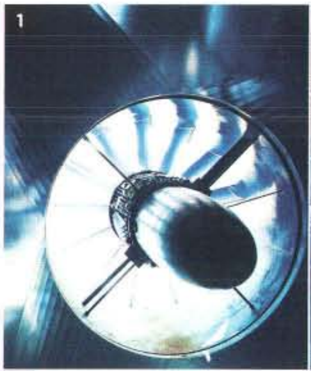

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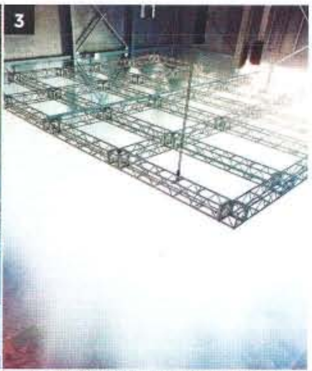

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Home wreckers

Anne Cope, research director at the Institute for Business & Home Safety, in South Carolina, has the power to unleash biblical plagues. "We crash-test buildings against Mother Nature," she says. The six-storey laboratory is so big you could build nine houses inside it – then destroy them. Gales, torrential rain and wildfires – all these disasters can be recreated at the institute. Here's how. **Eric Smillie**

1. FANS
An array of 105 individually controlled 1.5-metre fans blow 700,000m^3 of air per minute at speeds of up to 225kph – the equivalent of a category-three hurricane.

4. HANGAR DOORS
Must be open during tests, or the hangar could pressurise and explode. "The headlines would be bad if the safety research centre destroyed itself," Cope says.

2. FLAMES
Smouldering mulch embers waft up from a trench and are blown toward the dummy home. A mobile cage full of gas burners can blow radiant heat to simulate a neighbouring fire.

5. CONTROL BOOTH
Up to 80 technicians can watch the destruction through impact-rated windows, adjusting the wind gusts, rain ferocity and heat to match documented weather patterns.

3. SPRINKLERS
These rainmakers can release as much as 20cm of water an hour in droplets of various sizes. The centre also has a hail-maker that freezes pellets before delivering them at terminal velocity.

6. GIANT TURNTABLE
Want to test how each side of a fake domicile responds to catastrophic damage? No problem. Dollies can carry dwellings to a 16-metre-diameter rotating platform, which turns them.

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A CONNECTICUT YANKEE IN KING ARTHUR'S COURT A Gilded Age mechanic is transported back in time to King Arthur's court at Camelot, where he kicks off the industrial revolution 1,200 years early.

A PRINCESS OF MARS Its 1917 vision of Mars is cheesy. Four-armed green natives? Really? But it still makes for a great pulp-adventure story. Pixar's Andrew Stanton is working on a live-action film adaptation.

FRANKENSTEIN; OR THE MODERN PROMETHEUS OK, for the last time – Frankenstein is the name of the scientist. The creature is called Frankenstein's monster. Also, this is an absolutely gripping book.

GULLIVER'S TRAVELS Why read Swift's 284-year-old classic? Because Gulliver extinguishes a Lilliputian house fire by peeing on it, that's why. *All titles available at gutenberg.org* **Troy Brownfield**

The life-savers

Don't fight fire with fire – use cyanide antidote, hazmat suits and a non-sparking sledgehammer

Exploded meth labs, overturned tanker trucks, strange envelopes filled with white powder... they're all in a day's work for Rob Schnepp (*below*), a fire chief from Alameda in California. He literally wrote the book on how to deal with chemically sticky situations (*Hazardous Materials, Awareness and Operations*) and tours the world speaking on the subject. Here are a few tools of his trade. **Aaron Rowe**

THERMO SCIENTIFIC FIRSTDEFENDER RAMAN SYSTEM
A device that can instantly ID anything from cocaine to nerve gas. It zaps the substance with a laser and reads the wavelength that bounces back to determine what the stuff is. *£20,000*

ONESUIT FLASH PROTECTIVE SUIT
This rig is made from a fluoropolymer that blocks fire and toxic chemicals. At around 6kg, it's among the lightest of its kind on the market, though it still feels stiflingly hot inside. But it does come with free booties! *£1,800*

AMPCO SPARKLESS SLEDGEHAMMER
When you're hacking the door off a building that has a gas leak, a stray spark can really ruin your day. Fire crews use tools made of a copper alloy that won't cause sparks no matter how hard they are swung. *£85*

CYANOKIT CYANIDE ANTIDOTE
The poison in smoke kills thousands of people every year. We could save some by injecting them immediately with a large dose of hydroxocobalamin, which neutralises the cyanide belched out by structure fires. *£50*

REACTIVE SKIN-DECONTAMINATION LOTION
After a nerve-gas attack, you'll want a weapons-grade sponge bath. Each RSDL towelette has 2,3-butanedione monoxime and other ingredients that destroy everything from sarin to VX. *£12*

AREARAE WIRELESS GAS-SURVEILLANCE ARRAY
These gas monitors are essentially just Wi-Fi-enabled smoke detectors. You pop in sensor modules that detect everything from cyanide to sulphur dioxide and then leave them by, say, air vents. *£32,000*

PHOTOGRAPHY: JONATHAN SNYDER

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WARREN ELLIS

'We are getting more comfortable doing business with ghosts'

I'm in the middle of starting a new novel right now, and the bad thing about that strange phase of existence is that everything you see and hear somehow relates, in the wankmulch your brain has become, to that novel. Even a shopping list becomes a mass of notation and connective lines – because you're convinced that the six things on it reveal something phenomenal about the world and your place in it, and there's a place in the novel where you can shove all that in.

Deep down, there's a little James Joyce homunculus in our hearts, presumably chatting up a saucy-looking ventricle and asking it if it shags, and also spreading the beautifully toxic notion that his book *Ulysses* actually contains all of Dublin in it and, should it ever be destroyed, a new Dublin could be generated from it like a backup copy, if needs be. And so we peer around at everything, to see if we can image it on a hard drive of a book, ghosting the real world.

Also it's important to note that when writers – or at least I – get into this condition, we talk very fast and make not a lot of sense.

Ghosting the real world. That's something that appears in my notes early on. I really need to reserve some of this stuff for something else I'm working on, a long essay, but it's hard, because the material is crackling and present and rattling its chains. So much of what we do is mediated by ghosts.

We even learn to dance with them. In Hong Kong, prepaid public transport cards don't have to be shown or inserted into a reader. Women have learned to swing their handbags in a little set of steps that lets the RFID chip on the card get read over the air. Tens of thousands of women doing an artful little dance with their handbags and a ghost terminal every day. You could watch it on an AR-equipped phone, maybe, and watch the RFIDs bloom inside their handbags.

We are growing more comfortable with doing business with invisible things. There's something almost primeval about it. A sense that we're relearning to interact with the presence of the powerful and numinous. Working with the ancestors. There are already people working on adding historical AR overlays to buildings, sites, streets. One day you're going to be walking through Dublin and you'll raise your phone, your little ghost box, to your eye and peer through it at a certain building. And a Turing-tested James Joyce, put together from correspondence and recordings and *Ulysses*, will appear on your screen and ask you if you could lend him a tenner so he can buy you a drink.

We have worked very hard to create a (science-fiction) condition wherein we are in league with the invisible. (The Native American Ghost Dance, when first given to the Nevada Paiute, was intended to bring about reunion and communication between the living and the dead.)

Smartphone as scrying pool, holding it up to see the spirits move. John Dee would have loved the iPhone, because it's what he went to the scrying pool for: a reflective surface that, when operated in an arcane manner, would bring him intelligence from across the world through the spirit realm.

I have this notion that the iOS paradigm means that, one day, kids who want to talk directly to the ghost, rather than looking at the shiny mediating surface, will have to spray machine-readable code on walls that face CCTV cameras.

Many cultures believe that spirits travel in straight lines, but that they can be captured by a web woven over a framework, or perhaps by tangled threads contained in a glass bottle. Peculiar and powerful metaphors for the times.

It is the glory and the tragedy of the writer that, deep in the armpit of the night, all these things seem to make sense and whisper that they are all somehow connected. And so you shove all the tangled threads into a bottle, and hope to trap a ghost that will in its thrashing and convulsion weave them into a single braid.

This is also why writers drink a lot, and, therefore, why they always have an empty bottle to hand.

ILLUSTRATION: KRISTIAN HAMMERSTAD

MICROBIOGRAPHY

Warren Ellis is a prolific comic-book writer for Marvel and DC, as well as a novelist and commentator. You can read his blog at *warrenellis.com* and follow him at *twitter.com/warrenellis*

I AM TECHNOLOGY

From its race-car inspired dash to the treads of its tyres, the new Alfa Romeo Giulietta packs in more innovation, technology and class-leading power than ever before. Brains, brawn and beauty in one package? You bet

1. THE BEATING HEART

Five turbo engines

The heart of every Alfa Romeo has always been its engine. There are five different units in the Giulietta range, each of them turbocharged.

Most powerful is the 1750 TBi 235bhp Cloverleaf, a twin overhead camshaft, direct injection, variable valve timing engine, complete with a revolutionary ultra-precise "scavenging" control system that eliminates turbolag by monitoring and optimising fuel dosage, ignition advance and timing.

With record-setting performance, it provides more horsepower and torque per litre than any other four-cylinder petrol engine found in this class of car.

2. SEE AND BE SEEN

LED lights

Head- and tail-lights use LEDs, a choice that is both aesthetic and responsible since they are safer, stronger, more reliable, switch on faster and use less power than conventional bulbs.

The Giulietta also features Daytime Running Lights that will become a European standard in 2012. As soon as the car is started, its LEDs automatically turn on, maximising daytime visibility.

Headlamps

The optional AFS system points headlights in the direction the car is turning into – up to 15-degree turns – which mean maximum visibility and safety, even in tight turns.

3. INTELLIGENT CONTROL

DNA technology

Fitted as standard across the entire Giulietta range, intelligent DNA technology adapts the car to your needs in real time, regulating engine torque, steering and throttle response, front electronic differential and traction control.

Dynamic mode makes steering more responsive as well as giving you enhanced braking; Normal is for city driving, with a lively engine and Dynamic Steering Torque that controls oversteer; and All-Weather is designed for maximum safety in low grip conditions, offering enhanced sensitivity – which controls power delivery to the wheels, ideal when left and right are on differing surfaces.

4. STOPPING DISTANCE

Pre-fill braking

Designed to alert the Giulietta's braking system that you have taken your foot off the accelerator pedal, this decreases intervention time and consequently braking distance.

Recognising that the driver is about to brake, it works by automatically increasing the pressure inside the braking system. This reduces pedal travel by 30 per cent, ensures quicker braking response, and also makes the brake pedal the feel more like that of a racing car's.

5. DRIVING EXPERIENCE

Dual-pinion steering

The all new electric power steering system uses two pinions on the steering column. The control pinion mechanically connects the steering wheel and gearbox rack for direct and precise steering that feels natural. No additional filters between the wheels and your hands means that you truly feel the road.

The second power pinion transmits the torque generated by the electric motor to the rack, which means fuel consumption is three per cent less than on a regular hydraulic set-up, as well as offering variable performance depending on driving conditions and speed.

DRIVING PASSION

Class-leading performance – the new Alfa Romeo Giulietta is a car with brains as well as beauty, inside and out.

The original Giulietta was one of the great 50s motoring icons. A true classic. Fast-forward to the present day and, while the spirit and innovation is still there, the performance, handling and efficiency are all state-of-the art. Inside and out, this is the next evolutionary step in its class. The luxurious cabin is the control centre for a race-car inspired design – lighter, faster, stronger, with a perfect balance between comfort and sportiness. Steering is quick and direct, grip levels are high and handling agile. It even sounds the part, with a growl that evokes the famous Spider "Duetto" from the 60s. *Go to www.alfaromeo.co.uk/newgiulietta to find out more*

MODEL SHOWN: ALFA GIULIETTA 1750 TBI 235 BHP CLOVERLEAF AT £26,185 OTR, INCLUDING OPTIONAL GHIACCIO WHITE SPECIAL PAINT AT £490 AND ELECTRIC DOUBLE SUNROOF AT £1,200. RANGE OF OFFICIAL FUEL CONSUMPTION FIGURES FOR THE ALFA GIULIETTA RANGE: URBAN 26.2 – 51.4MPG (10.8 – 5.5L/100KM);EXTRA URBAN 48.7 – 76.4MPG (5.8 – 3.7L/100KM); COMBINED 37.2 – 64.2MPG (7.6 – 4.4L/100KM). CO_2 EMISSIONS 177 – 114G/KM. PRICES CORRECT AT TIME OF GOING TO PRESS.

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Compiled by Nicola Day

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1 Media Festival

If your industry is music, gaming, TV or anything media-related, you should get yourself to the Media Festival taking place in Manchester during November. For the third year running, it focuses on the rapid pace of industry change, concentrating on creative and commercial realities faced by the digital content industries. Seminar subjects include funding and investment, and understanding the potential of emerging disruptive technologies. The 2009 festival attracted representatives from Sony Music, Channel 4, Google, Spotify and other flagships of new media, broadcasting, film, arts and advertising. Scheduled speakers at the 2010 festival include the CEO of UK Music and the CEO of We Are Interactive. The event takes place on November 17 and 18. *For more information and to purchase passes, visit themediafestival.com*

CLINIQUE

Here at WIRED, we like our lasers – but we're still not that keen on zapping our faces with them in an attempt to keep our youthful good looks. Thankfully Clinique's latest addition to its Repairwear range claims it gives line-erasing results close to that of dermatological laser treatment. Combining repair enzymes and a cocktail of vitamins C and E and pomegranate, this twice-a-day treatment promises to roll back the years. *Repairwear laser focus, £35/30ml, clinique.co.uk*

MAP MARATHON

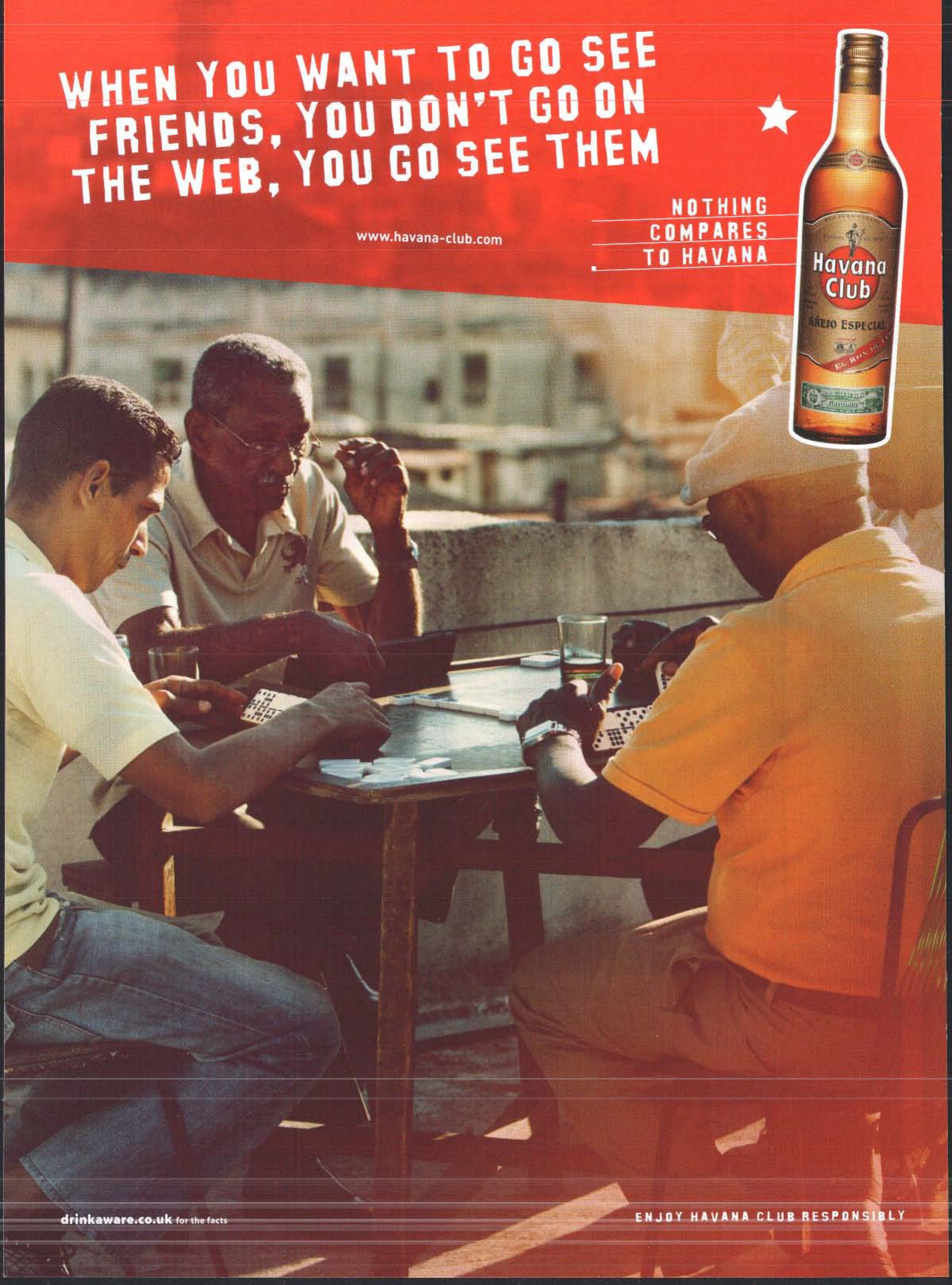
Get yourself down to the Serpentine Gallery for *Map Marathon: Maps for the 21st Century*, on October 16 and 17. This exciting event, concentrating on all forms of mapping data, space and time, multiple dimensions, language and the body, is bound to inspire some creative thoughts of your own. The fifth in its annual series of Serpentine Gallery events, this multidimensional mapping collaboration depicts geographical areas, mindscapes and digital realms alike, and expresses interconnected ideas and issues. WIRED is very pleased to be one of the event's chosen media partners in showcasing more than 50 talented writers, poets, artists, architects, scholars and musicians and their speculative maps for the coming decade. *For more information, visit serpentinegallery.org*

DUNHILL BIOMETRIC WALLET

If you worry about your wallet – and the security of its contents – perhaps a fingerprint-recognising billfold is for you. Dunhill claims its electronic biometric-reader wallet is virtually impossible to hack. Made from high strength carbon fibre, it is linked via Bluetooth to your mobile phone, and will sound an alarm if your phone is more than ten metres away. The interior features a steel money-clip and leather credit-card holder, and it comes with a software CD to initialise set up and a USB cable used to charge the reader and alarm mechanism. *For more information, visitdunhill.com*

IBM SUMMIT

As a media partner of the IBM Summit at Start in September, WIRED played an active role in discussions on sustainable cities, smarter businesses and future talent. The conclusions will guide UK enterprises, government bodies and communities. Don't miss our report in December's issue. *Ibm.com/uk/start*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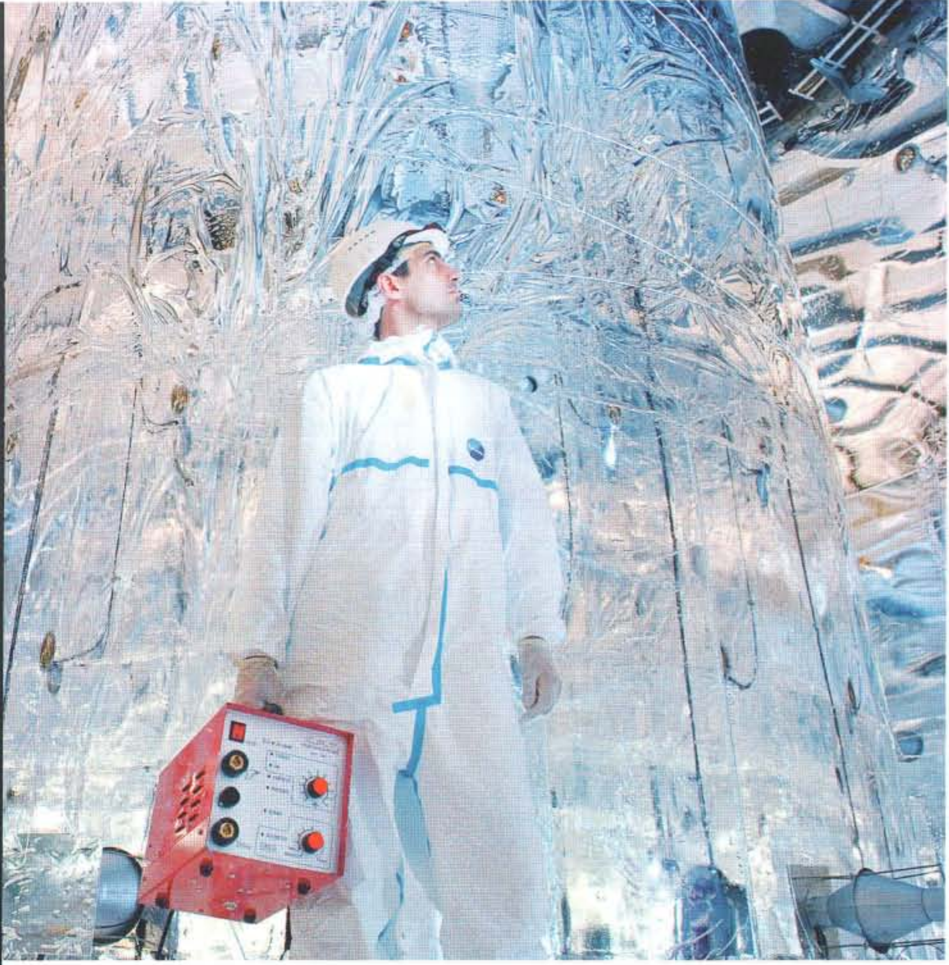

Searching for the invisible

Deep under the Italian countryside, two groups of scientists are disagreeing over dark-matter data

A team of physicists has published research that it thinks indicates the presence of dark matter, which comprises the "missing" 80 per cent of matter in the universe.

The team's experiment, called Dama/Libra and headed by Rita Bernabei, a professor of physics at Italy's National Institute of Nuclear Physics, has detected seasonal variations in their data. She and her team believe these are caused by dark-matter particles.

But the quest for dark matter (first covered in issue 09.09) is far from over. A rival team, also based at Gran Sasso (*pictured with technician*), near Rome, has published conflicting results. The Xenon100 team, co-ordinated by Elena Aprile of Columbia University, produced its first experimental results last spring and claims its observations contradict Dama's. "Xenon data cannot be comparable," says Bernabei. "The material and the phenomena observed are different from Dama's."

Aprile retorts that no other experiment can boast Xenon100's insight, but adds that competition is good for science. Perhaps the next few months will reveal who's right. There is one thing, however, on which the two teams seem to be in agreement. "The mystery of dark matter can be solved in the next ten years," says Aprile. "And it will take place at Gran Sasso, since no laboratories in the world can compete with it." **Nicola Nosengo**

PHOTOGRAPHY: EDOARDO DELILLE; MARCO PINARELLI

UNDERGROUND LAB

Bunker mentality

In 1979 physicist Antonino Zichichi had the idea of building a laboratory 1.4km under Gran Sasso mountain. Thousands of tonnes of rock shield the equipment from any interference that might skew the subterranean research.

Will the fat lady sing?

Two technicians inspect Opera, the detector at Gran Sasso that is dedicated to the study of another mystery of particle physics: neutrinos, small particles that carry no electrical charge, have half-integral spin and a very small mass.

Nobel calling

Gran Sasso, the largest underground research centre in the world, has three large rooms and around 15 different teams of competing physicists. Further researchers into dark matter and particle physics will be joining this year.

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play

- THE SOCIAL NETWORK
- CAT-SCAN SCULPTURES
- BALANCING BARNS
- SPEEDY LIFTS
- TYPEFACE BIOGS

EDITED BY CHARLIE BURTON

K9 IN 3D

In 2006 the internet went link-crazy over a single-take music video of the LA-based band OK Go dancing on treadmills. After racking up a million YouTube views in six days, the group was asked to perform the routine at the MTV Video Music Awards a month later. Now, with a string of viral successes under its belt, involving everything from Heath Robinson-esque machines to elaborate time compression, OK Go has

Turn page for more

PHOTOGRAPHY: BRAD SWONETZ

released its latest confection for the song "White Knuckles". The concept? "Dogs," says Damian Kulash, the band's 35-year-old front-man. "Dogs dancing."

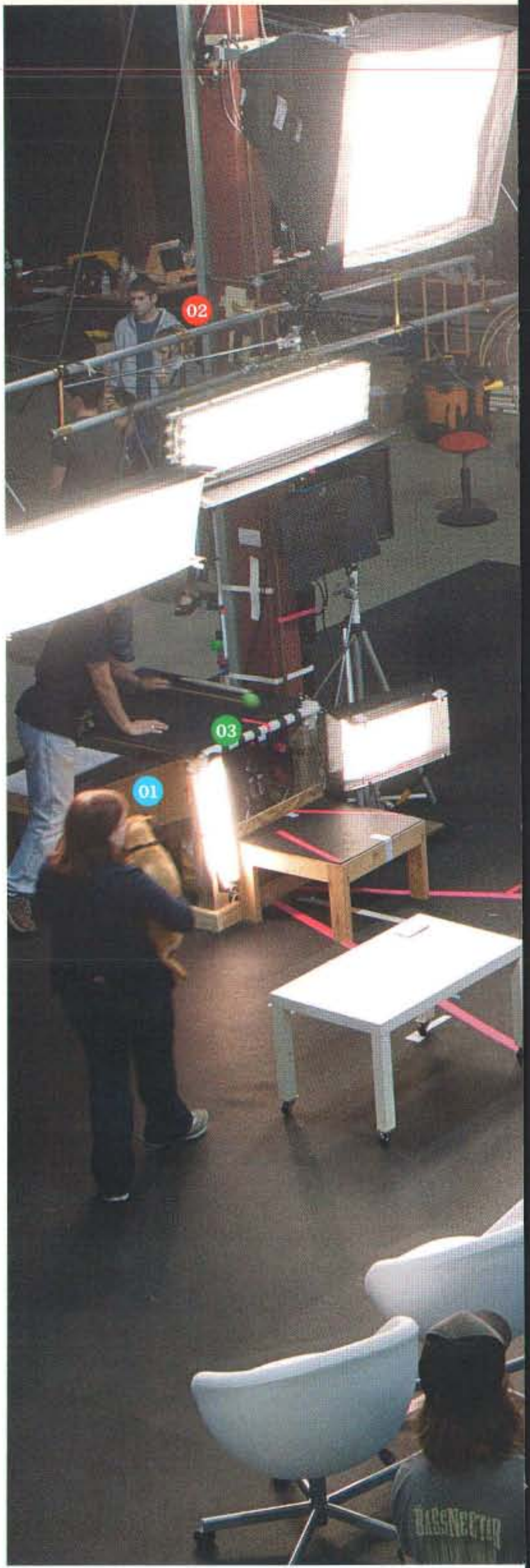
A video four years in the making, it is less about canines performing tricks than simple synchronised actions. But don't think that made it a cinch. "Having some task, running around, that's really easy. But just staying or being moved is really hard. If there's a larger theme connecting all of the videos it's choreography as a collaborative system. Like the beauty of an ant colony," he says. "The idea being that if you move one fork, you're moving a fork; if you take two forks, suddenly they're dancing."

Unlike OK Go's previous videos, though, this is the first to be filmed in 3D – using two hacked Canon PowerShot TX-1 cameras, with a control switch built into an Altoids tin. "To make things seem dynamic without a moving camera you've got to have these very big changes in depth: small, big, up high, down low, so there's so much using three dimensions already. These dogs look incredible in 3D." The video can be seen on YouTube in a host of 3D flavours (including red/green anaglyph and active shutter): since the band left EMI in March, it depends more than ever on viral appeal.

Working from two reference videos – one of separate clips cut together into the full routine, another of the band performing in a continuous take with stuffed animals – filming took place in Portland, Oregon over two weeks. Initially rehearsing at 80 per cent pace, the dogs were cued in by clicks of differing pitches from off-camera trainers, or were made to move in unison by waving a cheese-covered tennis ball attached to a long stick. It took more than 128 attempts (and they only started counting in week two).

Relying on live animals means the timing isn't beat-perfect. But to Kulash that homemade quality is key. "I had to make a 'What is an OK Go video' list for potential directors, and one of the main points is that it's something *anybody* could make. There isn't special access, or crazy skills, or a whole lot of money. If it's super-slick I think you believe it less." See the video at *wired.co.uk/okgo* **CB**

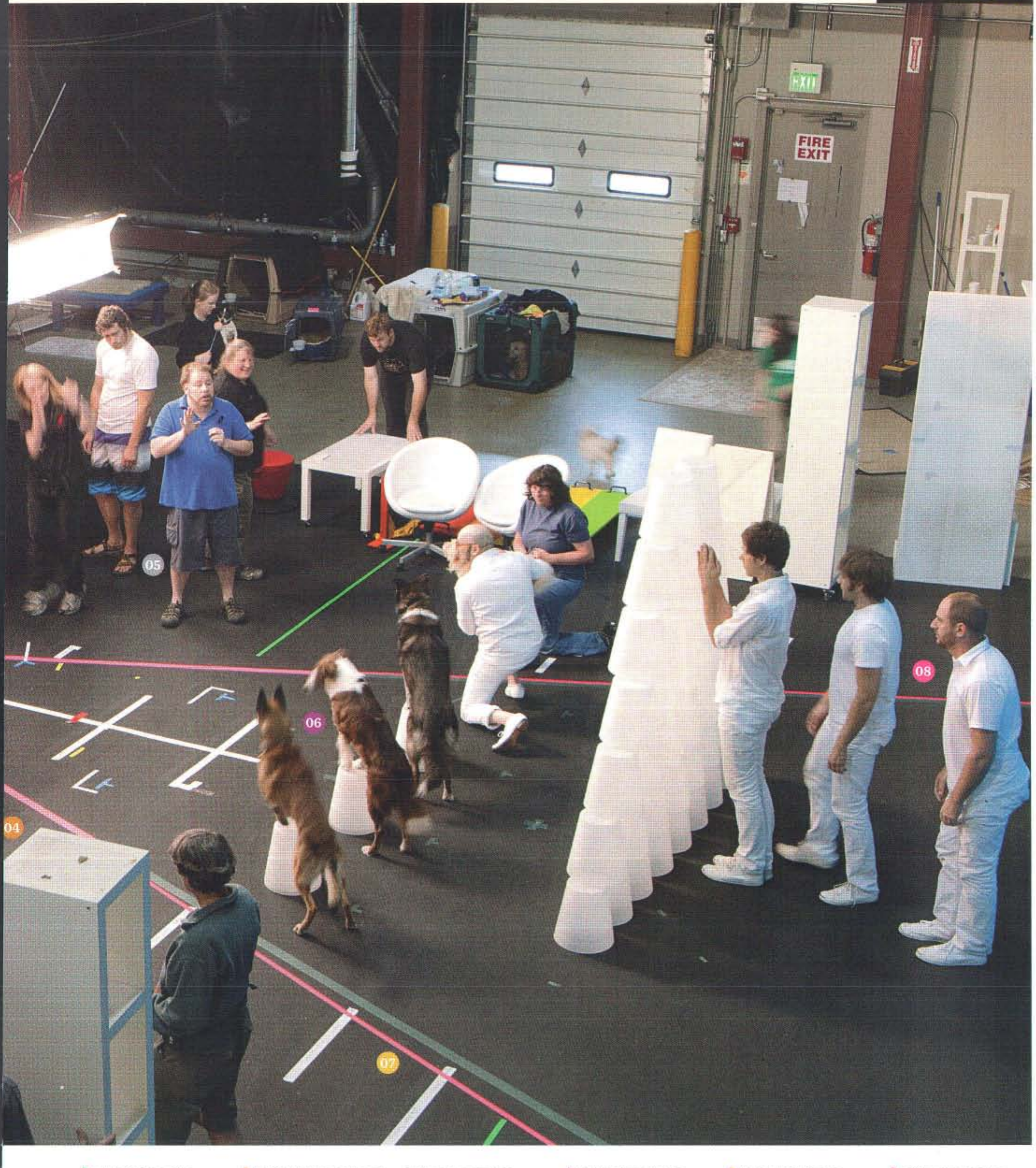
Here the boards are in the "marble-track" configuration, an echo of the previous Heath Robinson-style video. The lines on the floor tell the band where to stand at different moments.



1 Kulash's dog, Bunny, also appears in the video. Here, Bunny is being looked after by Jennifer, one of the trainers.

2 Kulash's sister, Trish, is codirector with her brother. She helped source the trainers over four years while working on TV projects.

A group of trainers called Talented Animals, based in LA, provided the dogs. OK Go started talking to the company in early 2009



3 The 3D rig sits below the standard camera. The step in front allows the dogs to jump straight over the lens when they run forward.

4 This "elevator" and the one on the other side of the frame are about to be pushed into view.

5 Each trainer is talking to a particular dog: (*from left*) Lauren and Aaron to Justice, Roland to Sequel, and Anne to Zuni.

6 The dogs (*from left*) are called Justice, Sequel, Zuni and Riot. Riot has just been handed to Nordwind.

7 The pink line is the edge of the 3D frame, while the green line marks the standard camera's frame boundary.

8 The rest of the band (*from left*) – Kulash, Ross and Konopka – are getting ready to take the buckets down.

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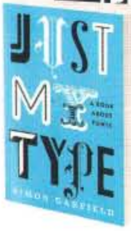


FONTS OF KNOWLEDGE

Simon Garfield's *Just My Type* is a font fanatic's dream, exploring the history of types and solving mysteries such as which font was used on the plaque left on the Moon by Apollo 11 (Futura, aptly enough). The author shares the stories behind five faces.

Doves

Garfield's top typeface has "the most bizarre tale". Created in 1900 for the Doves Press, the font was lost after bookbinder Thomas Cobden-Sanderson, fearing it would be used in "shoddy printing and undesirable subject matter" after his death, threw the whole letter fund into the Thames.

Transport

Used on UK motorway signs, Transport was made by Margaret Calvert and Jock Kinneir for readability at speed. It triumphed over David Kindersley's MOT Serif at a font-off where "a car displaying the two fonts drove towards a viewing platform". Observers had to say which one they could read first.

Gill Sans

Still used widely, this classic sans-serif was designed in the 20s by Eric Gill, a man obsessed with sexual experimentation, including with his daughters, sister and dog. "I still use it," says Garfield. "It looks exact and has a maturity to it. But then all we know about his lifestyle confounds all that."

Fraktur

A gothic script developed by the Nazis for Third Reich propaganda. Everything changed in 1941 when the regime outlawed gothic script by decree. "No one outside Germany could read their ancient Germanic heavy font, so they claimed, 'It's a Jewish font, we're going to get rid of it,'" says Garfield.

Bold 2012

"It's the worst," says Garfield of the official font for London 2012. "The Olympics are the ultimate in sporting beauty and athleticism, and this font is neither of those things."
Alison Flood

Just My Type *by Simon Garfield is out on October 21 (£14.99, Profile Books)*

● The top flap can hold a rolled-up poster ● Carbon-fibre rods support heavy objects, including bikes ● Military-grade nylon holds awkward cargo, such as frames

No-limit luggage

It's the next best thing to the Tardis: a backpack that gets bigger as you fill it

Courier pack, suitcase, carryall, tote, rucksack, shopper, daypack… enough already! Your personal electronic devices are converging – now your luggage is too. The Vandal bag's shape-shifting design lets it transform from 30-litre streetwear into 65-litre hiking gear, extend to hold a poster tube, carry pictures frames and hold collapsed bicycles.

"The main problem we were addressing was, if you live in a city and you're on a bike or public transport, [how to] buy groceries without carrying a really giant bag," says Bart Kyzar, 40, director of operations at San Francisco-based creator Mission Workshop. "Giant bags are not very convenient: you knock people's beers over or hit them in the head. This can tackle any situation that comes up." Sounds like our bag. **CB**
$239 missionworkshop.com

PHOTOGRAPHY: ANDY BARTER

CAPITAL COCKTAILS

London Cocktail Week explores the chemistry of mixology, the most delicious cocktails – and the best places to enjoy them

London Cocktail Week, which runs from October 11 to 17, promises to revolutionise your appreciation of the capital's best bars.

Register online for one of 5,000 free wristbands, which you need to collect from the London Cocktail Week bar at Selfridges, and you will qualify for £4 LCW cocktails in 50 brilliant bars around London, free transport on special LCW routemasters and deals and discounts all over town.

There will also be special ticket-only events throughout the week: seminars, tastings, masterclasses, parties and dinners – many of which are free – with tickets allocated on a first-come, first-served basis. Tickets can be bought and reserved at *londoncocktailweek.com*, and there is also a waiting list for the more popular events.

The wristbands are limited, so register for yours at *londoncocktailweek.com*. Keep checking there and at *wired.co.uk* for how you can win tickets to an exclusive talk by professor Andreas Sella and top mixologist Tony Conigliaro (*shown above*), where canapés and drinks will be followed by a fascinating look at the science behind cocktails.

Beefeater 24 is one of the sponsors of London Cocktail Week. This super-premium gin, created only a year ago by Master Distiller Desmond Payne, brings a new dimension to gin with its velvety-smooth taste, thanks to a rare blend of teas among its botanical selection. As the perfect ingredient for contemporary classic cocktails, Tony Conigliaro (*left*) has selected Beefeater 24 as his gin of choice for his gin-cocktail recipes that will push the boundaries of mixology.

LONDON
COCKTAIL
WEEK 2010

PHOTOGRAPHY: LEON CSERNOHLAVEK

Please drink sensibly.

drinkaware.co.uk
for the facts

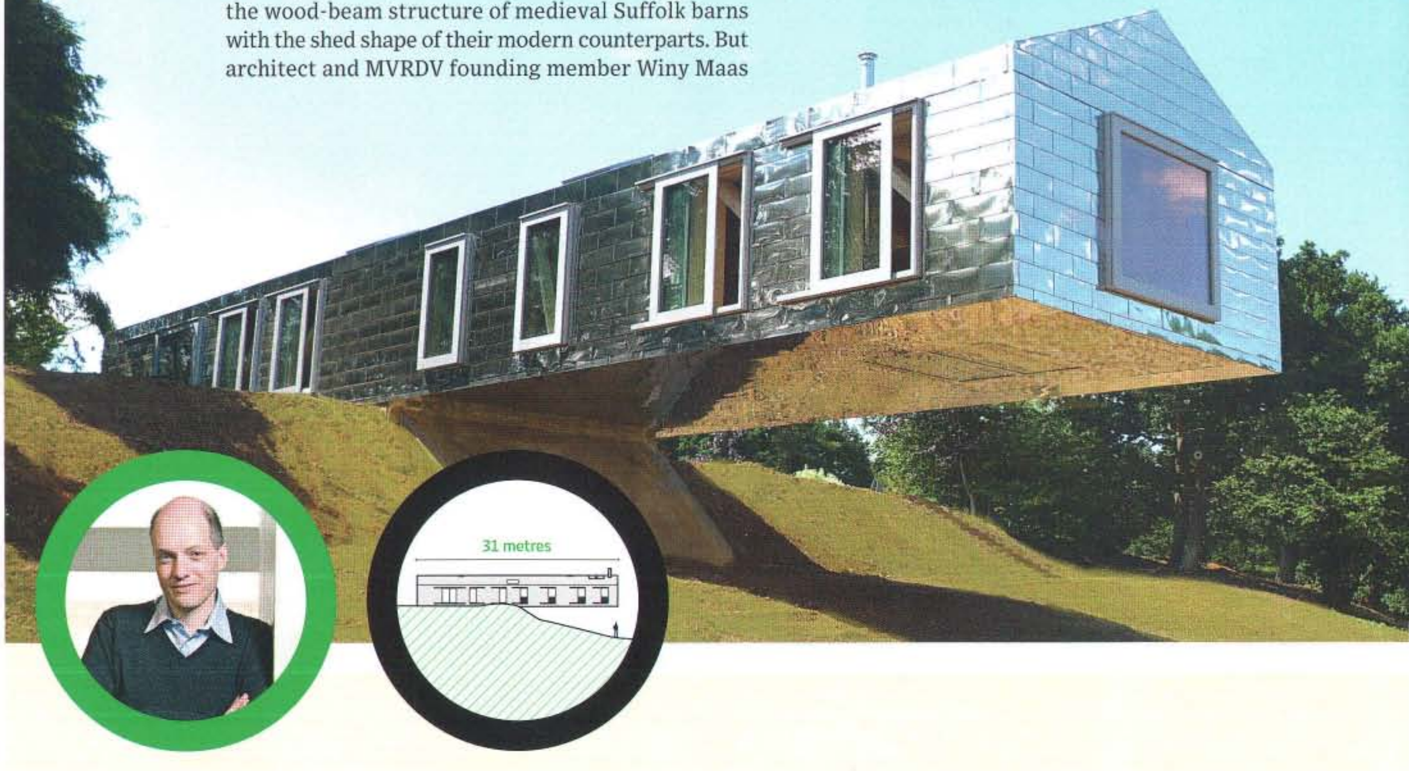
A holiday hangout

Alain de Botton turns architect with a gravity-defying Suffolk retreat

Cantilevering over the edge of a nature reserve, the Balancing Barn doesn't look like your average Suffolk holiday home. Which is the point. It is the first structure in the Living Architecture scheme, a not-for-profit initiative that offers the public the chance to rent a place designed by leading architects. The project is the brainchild of writer Alain de Botton (*inset below*). "Britain remains so resistant to contemporary architecture," he tells WIRED. "We thought it important to open minds and hearts."

De Botton asked Dutch architects MVRDV to design a building "in dialogue with its location". The firm blended the wood-beam structure of medieval Suffolk barns with the shed shape of their modern counterparts. But architect and MVRDV founding member Winy Maas pushed it further with panoramic windows, a reflective exterior and a floating glass floor: "You find a house which is partly stable and partly unstable," he explains. The balancing act is possible solely because of the zigzag beam structure in the walls.

De Botton writes about architecture in his current book, *The Architecture of Happiness* (Penguin), and makes a comparison: "Books cost little to write and can reach a wide audience. Buildings cost lots and reach few – and yet in some ways architecture has the advantage. The impact is deep rather than thin." Book a room at *living-architecture.co.uk* **TC**



THE DIGITAL COSTUME CHANGER

Listen up, Lady Gaga. Smart performers are transforming their appearance live on stage without a single new outfit or fleck of greasepaint. The source of these chameleon-like powers? A projection mapping system called Living Canvas. After three years in gestation, the technique is being used by Scottish theatre company Cryptic in an adaptation of Virginia Woolf's *Orlando*. Having flooded the stage with infrared light and captured the image on a high-speed camera, Living Canvas sees any element as a projection surface and allows the images to follow the player accurately.

Cryptic developed it with the Digital Design Studio at the Glasgow School of Art, and it promises effects that are new in live performance, says Cathie Boyd, Cryptic's artistic director. "It's made the scene where Orlando fights the police spectacularly chaotic. There's no way you could do that with prerecorded imagery, no matter how precise the actors' choreography." *cryptic.org.uk*
John Nathan

DEFYING LOGIC

Cattle ranchers in Paraguay want to cut down vast tracts of uncontacted Indians' rainforest and still portray themselves as environmentally responsible. How? Simple. Just call the islands of forests that are left 'nature reserves'. Help restore logic.
www.restorelogic.org/paraguay

Survival

Reg. charity 267444 Photo: © Rodrigo Baleia

Net-flicks we want

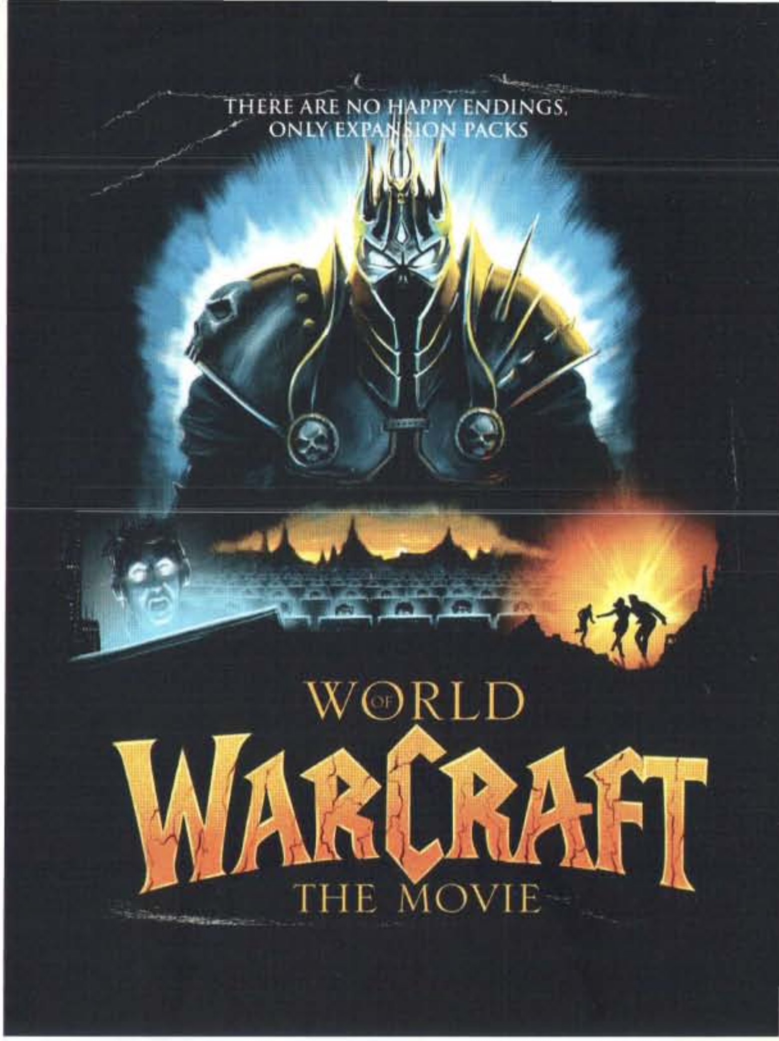
The Social Network brings Facebook to the big screen (see p146). So how might other net hits translate to the multiplex?

NAPSTER
Filmed on Location in: Nantasket Beach
Tag line: This time, Metallica aren't playing
The story: When Shawn Fanning helped people to share music, he didn't think anyone would object. Now Shawn isn't just running a file-sharing service, he's running for his life.
Starring: Napster as The Worst Thing Ever to Happen to Music
Featuring: The RIAA as The Other Worst Thing Ever to Happen to Music
Trailer track: "I Can Hear Music" by The Beach Boys
Happy ending? If you are a lawyer, yes

TWITTER
Filmed on location in: San Francisco
Tag line: I think someone's following me
The story: It's 2006, and Evan Williams is launching an exciting new service for people to share their thoughts online.
Starring: Ashton Kutcher as Stephen Fry
Also starring: Stephen Fry as Ashton Kutcher
Featuring: Google as Friendly Uncle Google
Trailer track: "We Share Our Mother's Health" by The Knife
Happy ending? Looking good, but there aren't many characters left

BLOGGER
Filmed on location in: San Francisco
Tag line: On the internet, nobody knows you're a blog
The story: Dear internet, today I found an easy way to publish my innermost thoughts on you. Tomorrow I'm going to find out that my boss read them. The day after that, I'll blog about that awkward conversation.
Starring: Evan Williams as the Blogfather
Featuring: Google as Rich Uncle Google
Trailer track: "Dear Diary" by Luna
Happy ending? Rich Uncle Google buys Blogger

FRIENDSTER
Filmed on location in: Mountain View
Tag line: I'm sorry. I only love you as a Friendster
The story: Sometimes it's not so good to be first to the party. Before MySpace, before Facebook, there was Friendster. Where is it now? Asia – as one of the biggest social networks.
Starring: Jonathan Abrams as the man who said no to Google
Featuring: Google as Snubbed Uncle Google
Trailer track: "Freak Like Me" by Sugababes
Happy ending? Well, there's a lot of people in Asia...



WORLD OF WARCRAFT
Filmed on location in: Azeroth, somewhere on a server farm
Tag line: Guild-y by association
The story: In 2004, Blizzard Entertainment launches *World of Warcraft*. Soon, every human being is plugged in to this breakthrough MMORPG, their physical bodies becoming nothing more than a power source for the sentient machines that now rule the Earth.
Starring: Michael McConnohie as the rumbling voice of the Lich King, Lord of the Dead, Ruler of the Scourge
Featuring: Bobby Kotick, CEO of Activision Blizzard, as the Lich King's less popular boss
Trailer track: "Some Kind of Wizard" by Biffy Clyro
Happy ending? There are no happy endings, only expansion packs
Stream "Sites and sound" at bit.ly/socialOST
Daniel Nye Griffiths

ILLUSTRATION: THEREDDRESS.CO.UK

HE BUILDS IN FOUR DIMENSIONS

Henry Segerman, 31, creates architectural forms (*left*) out of mathematical concepts, using the scripting tools of *Second Life*. Much like the dream-cities imagined by Christopher Nolan's architect in *Inception*, Segermen;s sculptural forms feature hyperdimensions, fractals, optical illusions and complex topologies. His working version of the house in Robert A Heinlein's sci-fi classic –*And He Built a Crooked House*, which morphs and rotates as you move through it, shows what it would be like to walk around the inside of a hypercube. "There would be no way to do this in real life," Segerman says. *segerman.org* Natalie Baker

THE CHAT-BOTS SPEAK OUT

Bot Colony characters speak in a style called "Literal", which enforces player speech clarity

For decades the games industry has failed to create a natural-language-processing engine that would let us have proper conversations with virtual characters. Now, Canadian company North Side claims to have cracked the problem in a sandbox game called *Bot Colony*.

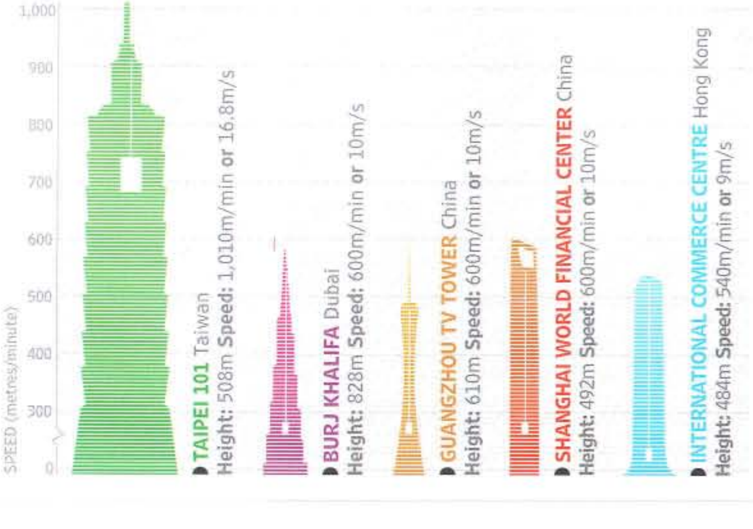
The brainchild of Eugene Joseph, who has made the natural-language engine available for those learning English, *Bot Colony* is conceived as a playable sci-fi novel. "It's an adventure game," says Joseph. "The game engine is simulation-driven and we have physics, so elevators move between floors and items remain where you left them when you restart. Also, you can teach robots to carry out physical actions, which is an exciting new element."

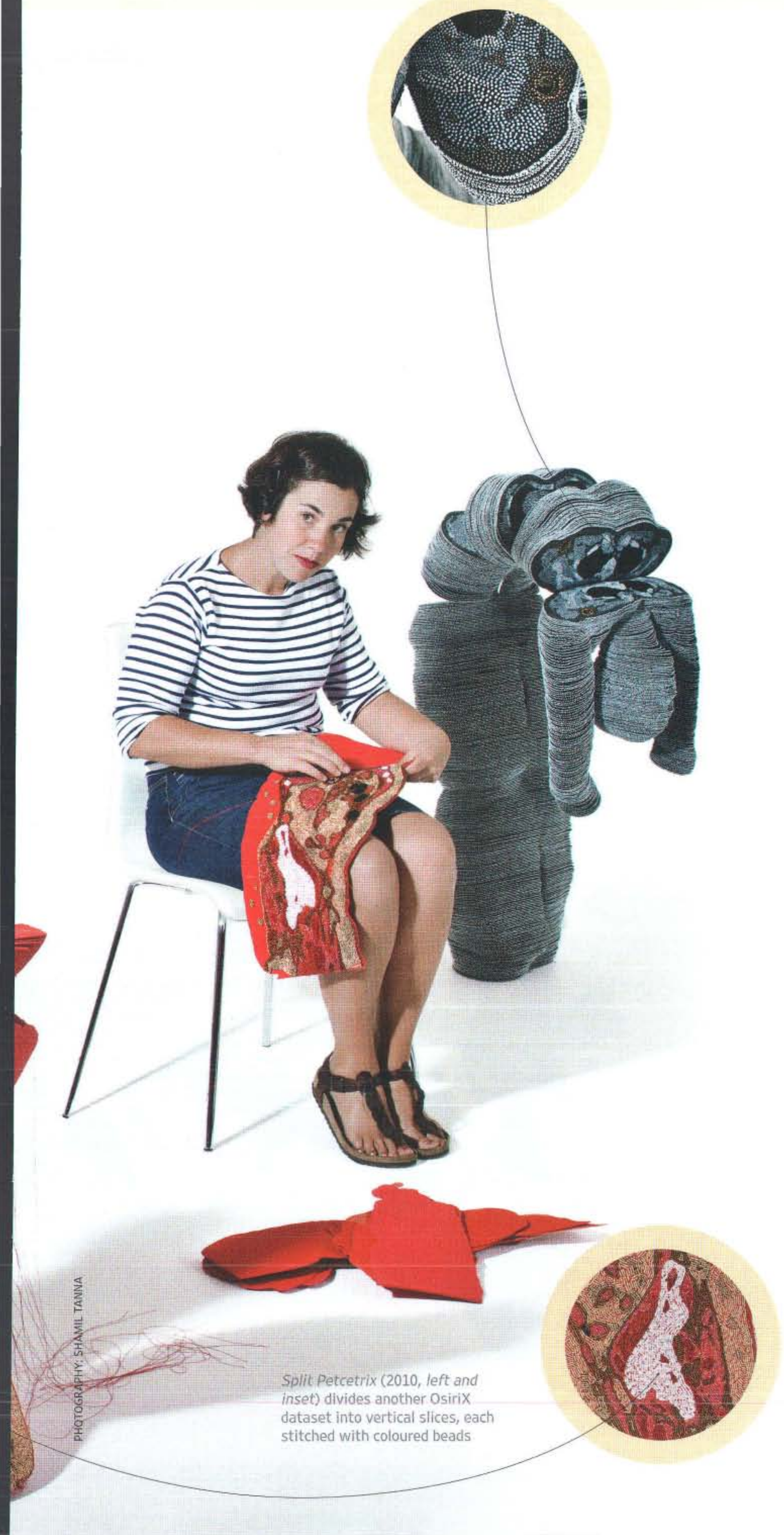
But how realistic is its natural-language engine? Joseph concedes that it wouldn't pass the Turing test, but says, "Language coverage should be fairly high, including idiomatic English, so it should be able to talk about almost anything. The real problem arises because computers lack knowledge of the world. The *Bot Colony* beta won't know The Beatles or Obama, though it shouldn't be hard to remedy this later by slurping in Wikipedia and other open resources. But it will be able to discuss a body of facts, such as the story, enough for a player to complete the game. And very importantly, it will be able to seek clarification when it doesn't understand you."

Bot Colony is poised to enter the open beta phase; you can sign up at *botcolony.com*. It will work on a client-server basis, and eventually charge a subscription: Joseph is aiming for $7 (£4.50) per month. A small price if it means abandoning those conversational pick-lists that blight otherwise state-of-the-art games such as *Mass Effect 2* and *Fallout 3*. Is it possible that our first conversation with a computer will be about the best way to frag? **Steve Boxer**

ELEVATOR SPEED HITS NEW HEIGHTS

The lifts in the Taipei 101 building in Taiwan travel faster than most cars in London, with a top speed of 1,010 metres per minute (60km/h). However, they may soon be overtaken – both Hyundai and Hitachi are testing lifts that can ascend at 1,080 metres per minute. Try not to miss your floor. **Alice Lighton**





Split Petcetrix (2010, left and inset) divides another OsiriX dataset into vertical slices, each stitched with coloured beads

PHOTOGRAPHY: SHAMIL TANNA

Inside-out artistry

CT scans of a stranger have inspired graphic sculpture

Marilène Oliver has spent two years crafting eight anatomically exact sculptures of the same woman. But she has never met her subject; she's not even sure she'd recognise her. Why? Because Oliver's pieces are based on a top-to-toe series of CT scans. The unidentified female in the work is distinguishable only by a small tumour in her left armpit. Oliver, a 33-year-old British artist who lives in Rio de Janeiro, found the dataset (known as MELANIX) in 2008 on the website of medical-imaging company OsiriX. Since then she has devised myriad ways to transform it from bits to atoms.

Take *Protest* (2010, *top left*), which comprises sheets of card: the CT scans are printed on the top; the UK Immigration Act is underneath. "I went to a talk by [US art historian and curator] Amelia Jones about an illegal immigrant who walked into Manchester County Court. I thought Jones said the woman disembowelled herself, but she actually set herself alight," says Oliver. "But it stayed with me, so I was thinking about how data could disembowel itself in protest."

This wedding of ephemeral data to physical violence is also central to *Orixa* (2010, *near left*), a foam-rubber version of the scans stitched around with beads. "There's an Afro-Brazilian religion called Candomblé, which has a night ritual where they try to call on their ancestors. In the morning the chosen ones receive the spirits and there's lots of photographs of them arching and falling back, being supported by the people around them." The dataset was made to concertina open in imitation.

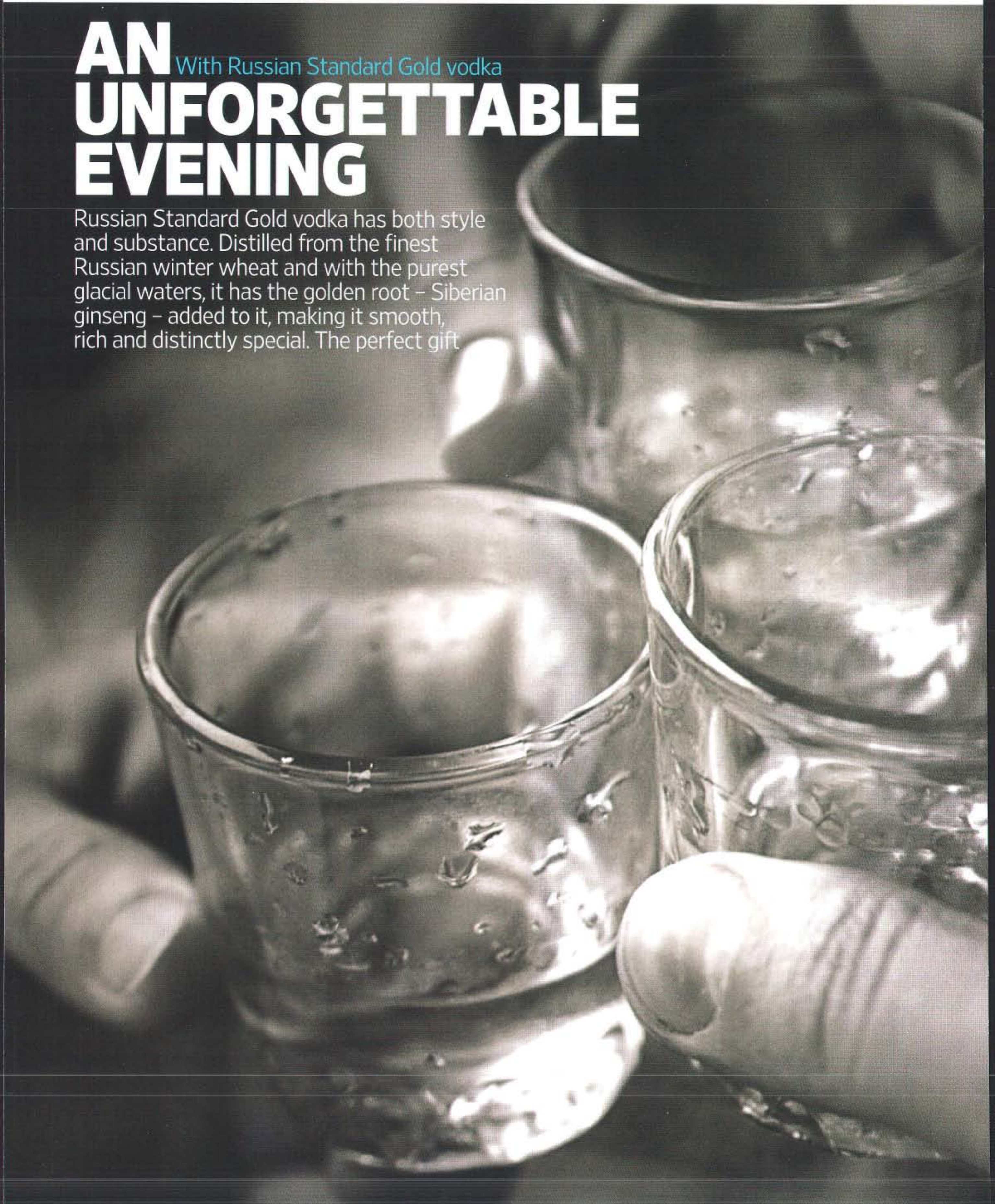
So is Oliver curious to meet the real MELANIX? "There's a freedom in not knowing who she is. If I was working with my mother's data, that's really loaded – there's only so much you can do. Like this they are self-portraits through another person's body." *marileneoliver.com* **CB**

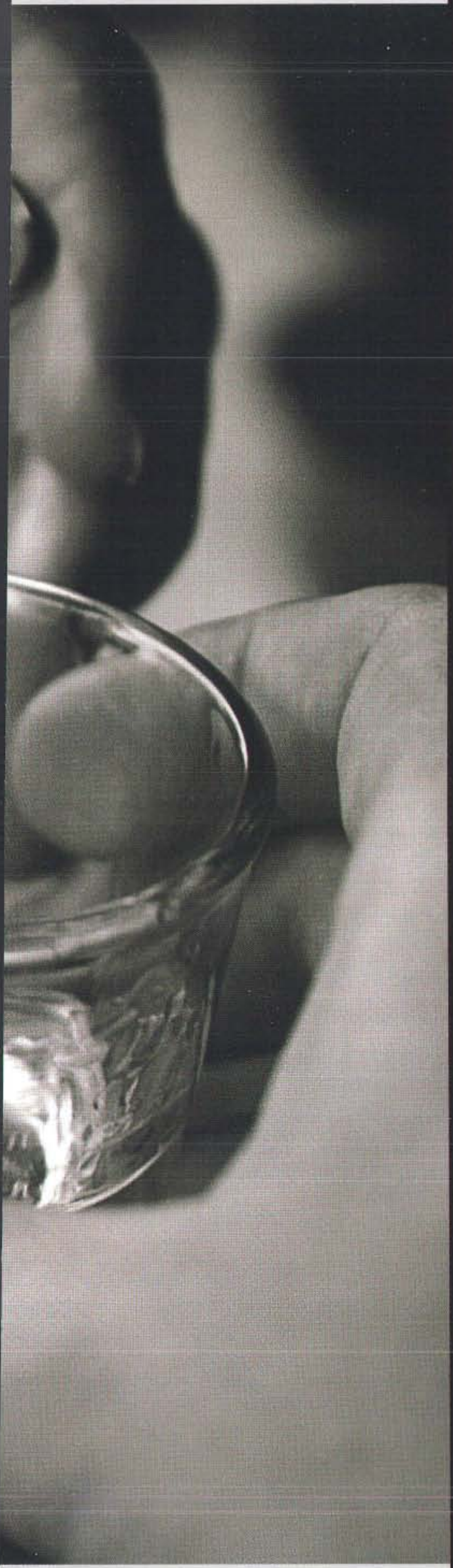
Oliver's exhibition, Carne Vale, *is at Beaux Arts London, October 6 – November 6. www.beauxartslondon.co.uk*

AN UNFORGETTABLE EVENING

With Russian Standard Gold vodka

Russian Standard Gold vodka has both style and substance. Distilled from the finest Russian winter wheat and with the purest glacial waters, it has the golden root – Siberian ginseng – added to it, making it smooth, rich and distinctly special. The perfect gift





A Russian-themed dinner party? Well that certainly piqued my interest. If Alexei is celebrating his roots, he'll be doing it in style. I couldn't just bring a bottle of Merlot to something special like this – I chose Russian Standard Gold Vodka. With its plush, gold box, it was the perfect gift. As I handed it to him, Alexei's eyes widened and all 6'5" of him crushed me in a bear hug. Turning around, he showed my offering to his friends like it was a trophy. Clearly, that's how you impress a Russian.

Alexei explained that Russian Standard is the only vodka that's smooth enough to drink neat, and that's why it's his homeland's top-selling premium vodka. What's more, the Russian Standard Gold had prompted a series of toast making. Not the "for he's a jolly good fellow" kind, but truly heartfelt toasts that gave a window into the soul of the speaker.

Sure enough, they started fairly ordinary, like "To us!" and "Here's to friendship". But by Alexei's third toast, I knew where he grew up, how old he was when the rest fell in love and his philosophy about what makes him truly happy. And in return, everyone had a chance to pour a round of Russian Standard Gold and give a toast, declaring things that were equally poignant.

Russians always serve food with their vodka. We started with hors d'œuvres or "*zakuski*". Caviar, smoked salmon and rich fish dishes were just a few items on the extensive menu. The party continued into the early hours but ended all too soon for me. So I made sure we could have the same experience again and invited everyone over to my house the next week to recreate the evening. You can be sure our group will enjoy the same food, the same tradition of heartfelt toasts and of course, the same premium vodka, Russian Standard Gold.

RUSSIAN TOASTS

Good health! (*Bud zdorov!*)
To the night! (*Za etu noch!*)
To friends! (*Za druzei!*)

ZAKUSKI

Hors d'œuvres, or "*zakuski*" in Russian, are a central part of any Russian gathering. Colourful bites, such as salads, cured meats, smoked fish and gourmet pickles are the perfect accompaniment to a genuine vodka experience.

THE RUSSIAN STANDARD GOLD TASTE

The ideal vodka for a special occasion, Russian Standard Gold is one of the world's smoothest and most enjoyable vodkas. Its Siberian golden root extract, or ginseng, provides a rich profile – from subtle sweet hints to a soft but bold flavour.

CREATE YOUR OWN EVENING WITH RUSSIAN STANDARD GOLD

Find Russian Standard Gold with its gold embossed gift box at all leading retailers including Selfridges, Morrisons, Sainsbury's, Tesco, Waitrose and Fenwick. But first, a few tips to help create the perfect Russian evening:

- **Encourage your guests to make a spontaneous toast with each glass of vodka**
- **Serve something to nibble on at the start of the night**
- **Ensure you serve Russian Standard Gold, the perfect vodka for adding exuberance to any special occasion**
- **Store your Russian Standard Gold in the fridge, not the freezer, and try it neat to savour the smooth and authentic Russian taste**
- **Impress everyone with your choice of vodka when you say that Russian Standard is Russia's No.1 premium vodka**

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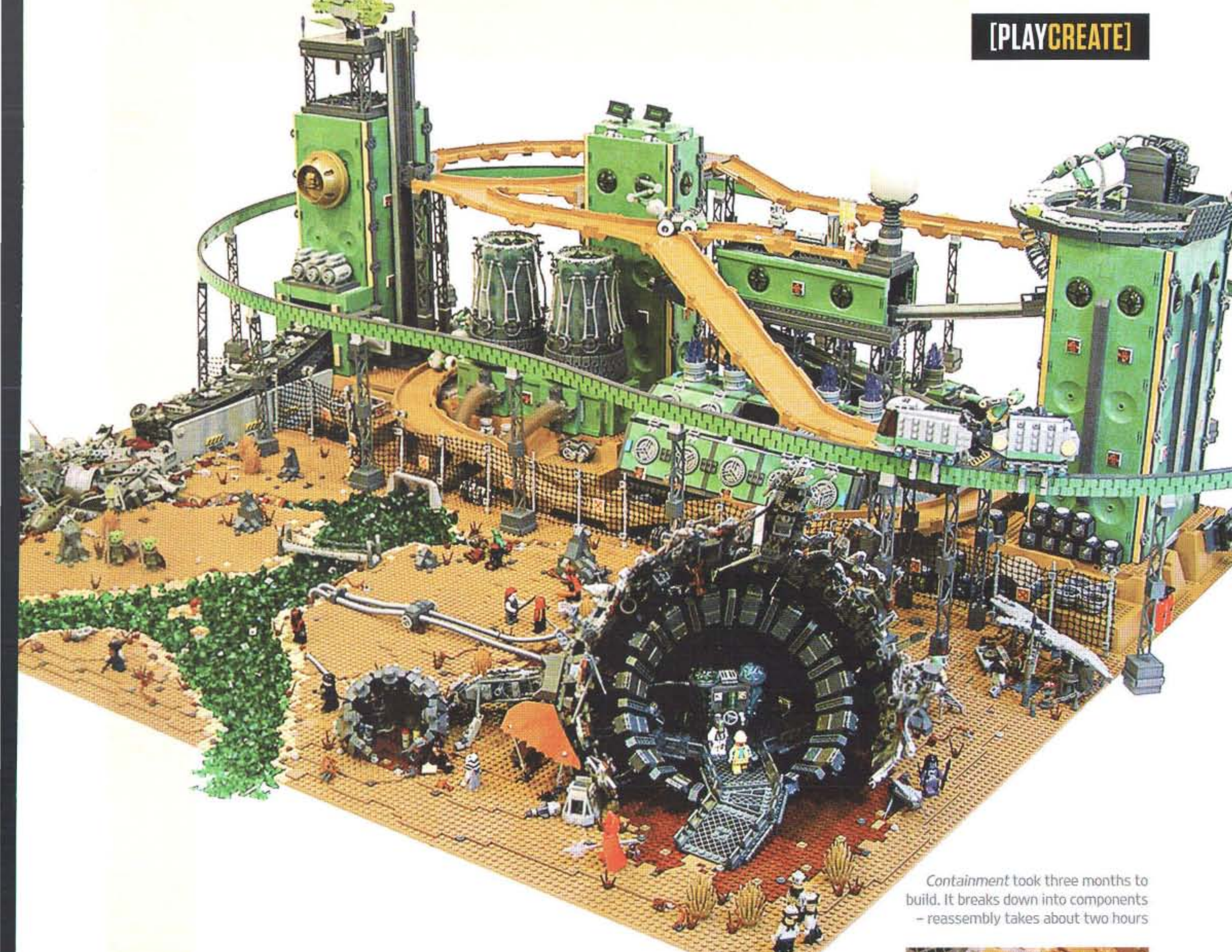

Containment took three months to build. It breaks down into components – reassembly takes about two hours

Last Lego standing

Two builders unveil their post-apocalyptic play-set

It's the end. A lone survivor of an unknown calamity and his robot assistant press on, making sure the processing facility (*right, bottom*) keeps, well, processing. A tram runs, conveyor belts turn, and a toxic river flows. The landscape encroaches, held back only by an electric fence. A crashed vessel juts from the ground. Creatures have claimed it as a shelter.

It's a chilling post-apocalyptic vision – or as chilling as one made from Lego can be. The giant diorama, entitled *Containment*, was built by Tyler Clites and Nannan Zhang, and unveiled at Brickworld, the annual Lego-building convention held in Chicago. More than two metres across, it features flashing lights, audio and a working mono-rail. Many of the details are nods to other Lego architects and dioramas: the figure chiselling at a rock sculpture (*right, top*) is a tribute to late Lego builder Nate Nielson, and the monkey (*right, centre*) is a homage to a sci-fi Lego construction called *Omicron Weekend*.

The scene, Zhang says, is designed to leave us wondering what exactly is being contained – the isolated facility or the chaos outside. "That's a question for us all to answer," he says.

Justin McLachlan

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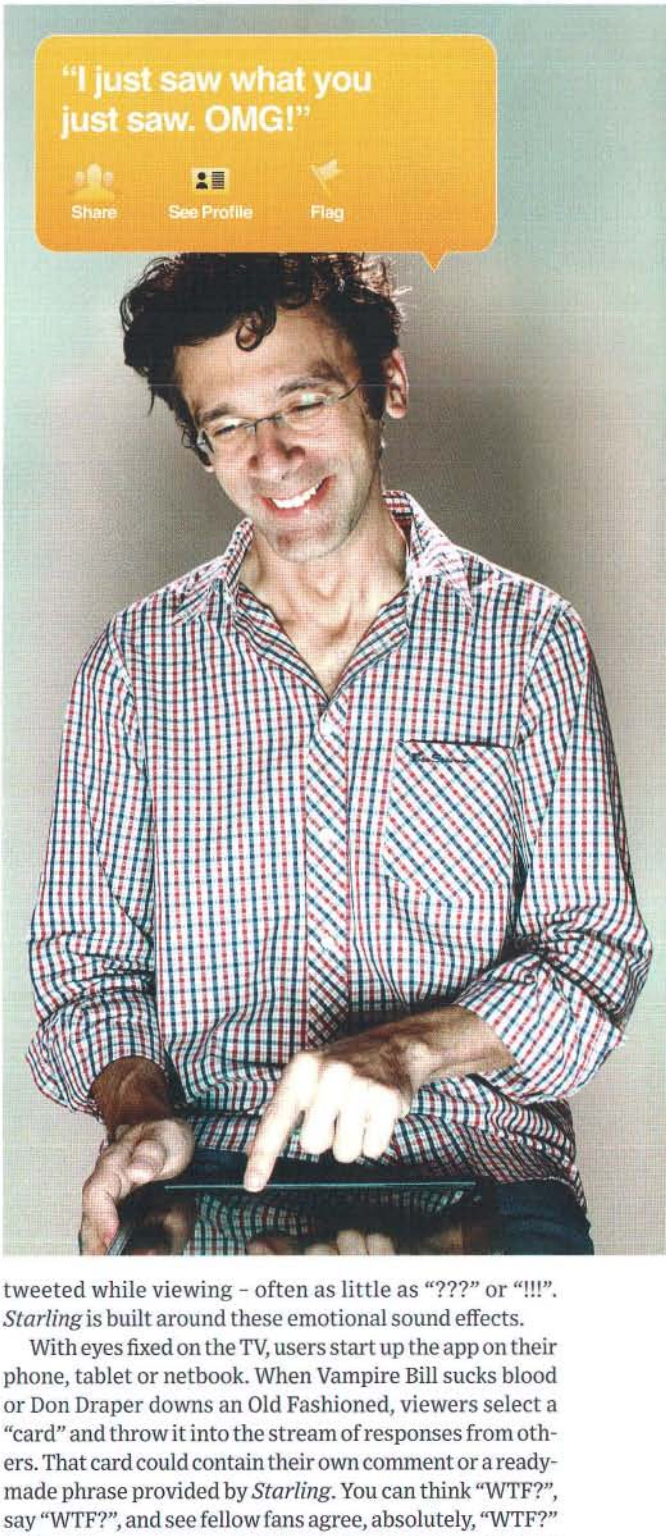
"I just saw what you just saw. OMG!"
Share
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See your thoughts fly

An app can put all your TV chatter into context

In the US, starlings are an unloved interloper. The result of a bizarre 1890 attempt to introduce every bird ever mentioned by Shakespeare into America, they move in their thousands in huge, noisy flocks.

The *Starling* app created by New Yorker Kevin Slavin (*above, right, with general manager Kenny Miller*) channels the idea of a giant flock, this time of people all talking at once – but gives it a potentially lucrative focus. Big TV events can lead to thousands of tweets going out every second, following the action. "It's empty and cluttered at the same time," says Slavin, 41. "It's like a room full of people talking – not all of them speak your language, others are just using the same words in a different context."

To filter the firehose, he looked at what people tweeted while viewing – often as little as "???" or "!!!". *Starling* is built around these emotional sound effects.

With eyes fixed on the TV, users start up the app on their phone, tablet or netbook. When Vampire Bill sucks blood or Don Draper downs an Old Fashioned, viewers select a "card" and throw it into the stream of responses from others. That card could contain their own comment or a ready-made phrase provided by *Starling*. You can think "WTF?", say "WTF?", and see fellow fans agree, absolutely, "WTF?" before the scene has ended. By looking at the timeline and the piles of cards, fans – and TV executives – can see where a show, event or commercial connected with its audience.

Slavin is already considering what else to enhance by sharing excitement in real time. "We want to amplify what someone's watching by adding participation. To improve an experience, just add people."

The app is available now for iPhone and iPad, or accessed via *starling.tv* **Daniel Nye Griffiths**

Post this

Reply

PHOTOGRAPHY: TIMOTHY SACCENTI

PLAYLIST

CULTURAL PICKS OF THE MONTH 11.10

FASHION MEMORY GAME

Cards go couture in Street Style Memory Game, which features the top and bottom halves of fashionistas shot on the streets of Amsterdam. Play with friends or just admire/sneer at the sartorial decisions. €12 *bispublishers.nl*

PINBALL MAGIC

Pinball wizards, get your drop stop ready. The *Pinball Magic* app, together with its cabinet "[app]cessory", is an arcade machine without the price tag. Yes, it's tiny, but the buttons work. $39.99 *newpotatotech.com*

BERG SILVER RACER

This retro pedal kart might look like kids' stuff, but don't be deceived. Its metal spoiler, race rims, pivoting front axle and pneumatic wheels offer a great-handling ride. It's also a limited edition, for Berg's 25th anniversary. *bergtoys.com*

KLIK KLIK ACCESSORIES

Klik Klik's jewellery puts you at the design table. Its Geomag-like system of neodymium magnetic cubes, wands and spheres form as many shapes as you can imagine, such as the Eva bracelet (*pictured*). $65 *klikklikjewelry.com*

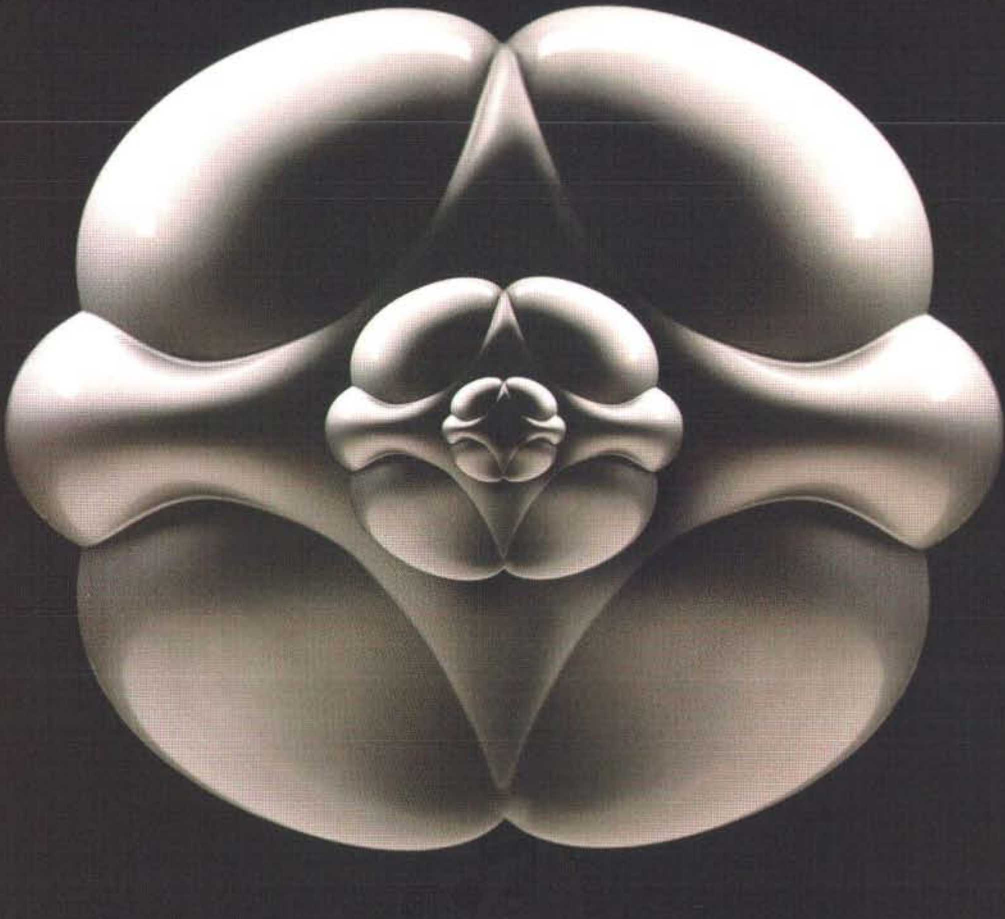
SMALL CRAFT ON A MILK SEA

After a five-year gap, Brian Eno has new solo album, made with Leo Abrahams and Jon Hopkins. Review copies were unavailable when WIRED went to print, but Abrahams says it's "live and alien". Out November 15 *brian-eno.net*

THE ORB

FEATURING

DAVID GILMOUR



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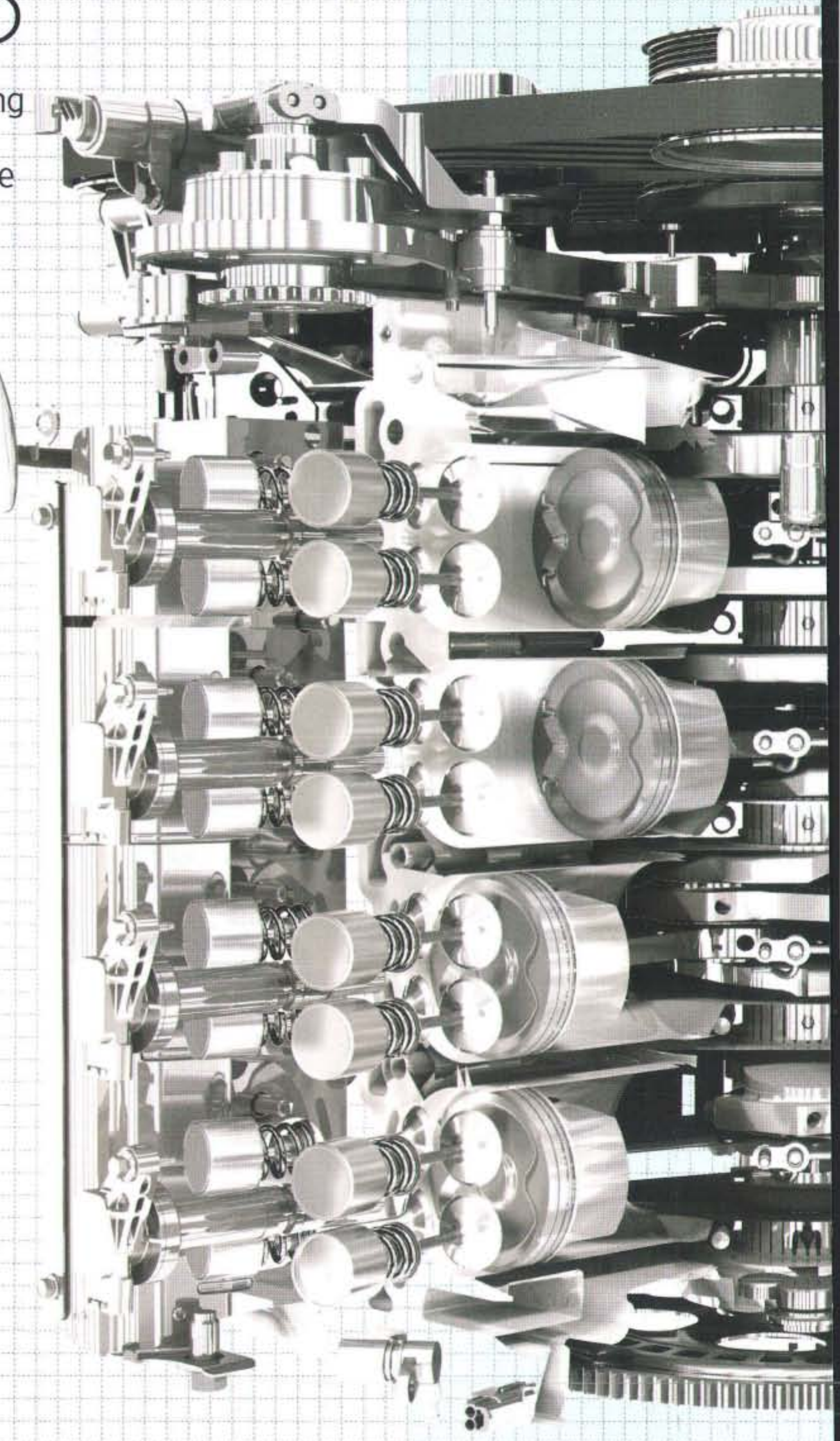
Advanced performance needs intelligent design – the new Jaguar XFR balances hard-edged sports handling with the refinement of a luxury ride. Its supercharged 5.0-litre V8 engine (*right*) delivers an explosive 625Nm of torque through its six-speed ZF automatic transmission, but is very smart with its power. Adaptive Dynamics calculates road-induced body movement 100 times a second, and wheel-hop 500 times a second, continuously varying the damping to ensure the best possible road-hold. Every engine in the award-winning XF range boasts enhanced power and performance, delivering Jaguar's most advanced and most efficient vehicles ever.



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FIND OUT MORE

These are only a few of the Jaguar XF's innovations – both the petrol and diesel models are packed with technology and design innovation. Learn more at **JAGUAR.CO.UK/XFR** or call 0800 169 4392.

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PHOTOGRAPHY: TODD ANTONY

how to...

...network more effectively

Informal get-togethers can drum up work, finances and career opportunities. So how can you maximise their potential? Brad Burton, MD of 4Networking, which organises over 200 networking groups nationwide, offers his tips. **Ben Beaumont-Thomas**

●

Be yourself

"Forget trying to appear 'business-like'," says Burton. "Wear what you normally wear – if people dismiss you for wearing a T-shirt, they're deselecting themselves."

●●

Treat everyone equally

"Perhaps it isn't just a carpet-cleaner you're talking to – maybe his brother-in-law is MD of the company? You just don't know who people know, so be respectful."

●●●

Know your stuff

Prepare a brief-but-memorable "elevator pitch", and know your product or service inside-out. "Be approachable and passionate about what you do, but don't bore people."

●●●●

Get over your fears

"It can seem a bit like a school disco," admits Burton. "You've got all these people around the outside and nobody prepared to dance. Be brave and jump straight in."

●●●●●

Don't expect instant sales or dozens of useful contacts

"You need to dance around the handbag a bit before you ask someone to come back to your place for a cuppa – the same applies to networking," says Burton. "You can't treat it like a vending machine where you press a buzzer and you get a load of work out of it." And forget hoovering up piles of business cards. "They either gather dust or lead to your spamming everyone. Go there with the express intent of coming away with one decent contact, and that's it. Someone whose business card you really want, someone you're actually going to call."

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ILLUSTRATION: YUM YUM LONDON

+ WIELD A WALKING STICK / WIN ONLINE AUCTIONS / MAKE MOVIES / GET FOUND BY SEARCH / GET ON TV

HOW TO...

wield a walking stick

Gang of ne'er-do-wells trying to relieve you of your consumer electronics? Self-defence skills blunted by never actually having learned any? Holding an umbrella? Then deploy "The Walking Stick Defence", an anonymous Indian police officer's 1923 guide to bringing the pain, using only lightweight dandyish accessories. In his words: "Imagine the discomfiture of the burliest ruffian on sensing the deft manipulation of what appeared to him to be merely a harmless little walking stick!" **BB-T**

ILLUSTRATION: MATTHEW CRUICKSHANK

PRACTICE

Grip your new weapon and hold it straight up in the air, angling your wrist so it's pointing downwards (an effective if odd-looking defence in itself); then swing it around by circling your wrist. (The guide says "something after the style of a Catherine wheel", but imagine Jet Li showing off with a lightsaber and you'll get it.) Also try turning it back and forth horizontally over your head. Practise over and over (probably not in a public place), until you're nimble. If your wrist gets tired too quickly, find a lighter weapon.

DEFENCE

Always hold the stick with your hand at eye-level, so that most of it is pointing downwards – it might feel unnatural, but it's the strongest defensive stance, and it creates valuable space. If someone is bringing their fist or weapon down on you, grip your own weapon tightly and use it to meet the descending blow; then, hopefully, you can use your newly deft wrists to respond with an attack. And be aware of the weighting of your feet, so you can easily step back out of the way of flying punches or knives.

ATTACK

Inflict maximum pain by striking wherever bone is close to the skin: shins, elbows and hands. If you aim for the head, try to come down on top of it. Return to your defensive pose after each attack, bringing your hand back to eye-level; if you get carried away, then your blows are likely to lose power and you'll become exposed. As well as allowing for swift defence, quick "flick" attacks hurt more. And remember: you didn't start the fight, and you don't have to finish it – "screaming" and "running away" are perfectly acceptable.

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HOW TO...

WIN ONLINE AUCTIONS

Desperate to bag that collectable *Star Trek* plate? You can play the auction system using psychology and simple tricks. Michael Conroy

DON'T GO FOR LOW

Auctions starting at zero can escalate into a bidding war that over-inflates the price. Look for auctions with a fair set reserve.

SEARCH SMARTER

Misspelled listings get lower traffic, so are cheaper: a study of 33 "Micheal" Jordan shirts found they sold at half the usual price.

WHEN DOES IT END?

From 5pm–9pm, eBay is busy, but the bidding is spread out, so you can still win. And look for auctions ending in the quiet, wee hours.

KEEP IT SHORT

Longer auctions allow for increased participation, driving up prices. Short-period auctions are cheaper, and the sellers keener.

BE STEALTHY

Bide your time – early bids attract attention. In the dying seconds, bid odd amounts such as £10.37 – even pennies can win it.

LOOK ELSEWHERE

Do some research – you may be able to buy what you want for less than auction price from an Amazon or Google reseller.

ILLUSTRATIONS: LEANDRO LIMA; HANIBOI

HOW TO...

be a movie mogul

Whether it's filming your child's sports day, putting together some promotional material for your business or creating a no-budget, ketchup-enabled splatterfest, you don't want to spend loads on equipment and software. But if you're smart about shopping, shooting and editing, you won't need to. **BB-T**

BUY YOUR CAMERA

Lori Grunin, senior editor of digital imaging at cnet.com, explains what to look for in an HD camera: "If you're shooting at what's described as 1,920x1,080 HD, check the camera-sensor can handle probably about two times that," she says. "The minimum illumination specs show low-light recording capability – ignore any special low-light modes as they use slower shutter speeds that can negatively affect video quality."

Grunin advises avoiding zooms of more than 20x, as they often have poor-quality lenses; 5.1 surround-sound recording, as you'll rarely need it; and large built-in memory (just upload your footage more often).

The design and interface are also important – it must be comfy and easy to use.

PLAN YOUR SHOTS

Storyboard your scenes and get plenty of coverage. "You want a master or long shot [the whole scene played out], and a medium shot, from the waist to the top of the head," says Elliot Grove, organiser of the Raindance Film Festival and tutor to novice filmmakers. "Then do close-ups of the person talking, and cutaways."

MOVE THE CAMERA

Static shots can be dull and cold. Use wheelchairs and skateboards to move your camera smoothly – or improvise a Steadicam. "I put my arm in a sling, and that gives me a good, solid mount," says Grove. "I rest my other elbow in my hand, then I walk – it creates a smooth tracking shot." Avoid zooms – they're cheesy.

DON'T IGNORE AUDIO

"The sounds make the pictures," says Grove. "Spend much more time on the audio than you do on the images." Don't worry if you need to rerecord dialogue after filming; just remember to record some of the sound (or "atmosphere") of the room you filmed in, then lay it under the newly recorded voices to keep continuity.

START EDITING

Don't buy expensive pro editing software – bundled programmes such as iMovie are fine for shorts. Grove starts by trimming away weak footage, so there is less material to organise. "Find one shot in a scene of a minute or two that tells the whole story. Drop that on the time-line, then cut into it with the close-ups."

get found by search

Search engine optimisation (SEO) is the process of making a website appear more prominently in search-engine results, and it's a battleground for anyone who relies on eyeballs on websites. If you're a casual blogger you may have never heard of it, but with a bit of simple SEO tweaking, you'll see your hit rate rise rapidly. **BB-T**

▲

USE KEYWORDS

These are the words that someone types into the search bar – and what Google looks for on your page. "In case someone's looking for 'David Cameron', make sure your page mentions 'David Cameron'," says Ben Hazell, SEO magician and audience developer at telegraph.co.uk. "Many blog posts discuss topics without mentioning the subject."

Google Insights can show you whether one phrase or wording is stronger than another: "Are people searching for 'Conservative' or 'Tory'? That points to how you should describe your content."

Lay the keywords out intelligently: "Things towards the top-left, and in the main column, tend to have more weight than things around the outside," says Hazell.

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GO BEYOND THE POST

"Put your strongest keywords in your window title, URL, headline and post text – that demonstrates a clear pattern of relevancy," says Hazell. This metadata contributes to your search profile. Optimise your images for picture search by tagging them and using strong keywords in description fields, filenames and captions.

ILLUSTRATION: MILES DONOVAN

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FIND A FOCUS

"If there is something that is popular with people searching, chances are it'll be popular with people writing about it," says Hazell. "So be more specific. 'Bafta awards' will be covered, but you might try 'Bafta awards red carpet dresses'. There are fewer people looking, but a better chance of doing well."

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USE SPECIFIC LINKS

"Links that say 'click here', or 'read more' are generally a bad idea," says Hazell. "Instead, match the title of the page the link points to. This helps demonstrate what a page is about to a search engine." Again, this increases your page's relevancy, greatly improving its chances of being spotted and ranked.

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USE GOOGLE ANALYTICS

Google Analytics is a free piece of software that tracks the visitors to your site. "It gives you info on where readers are coming from, what search terms they're using and how long they're staying," explains Hazell. "Once you have that information, you can improve on what the audience is looking for."

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UNDERSTAND SITEMAPS

Hazell recommends this extra bit of work to seal the deal. "A sitemap is basically a big list of all your pages, so Google knows where to find them. It's you providing an index of your own stuff and telling Google, 'This is my list, make sure you aren't missing anything from it.'" It's helpful for them, and gets you noticed.

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NOW WRITE SOME BRILLIANT CONTENT

Links pointing at your site from outside tell Google that your site has authority on a subject, and your position in search ranking will go up accordingly. As those links are beyond your control, the only way to get them is to create top-quality, compelling content that people want to link to.

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THE FIRST IN OUR SERIES OF TED FELLOWS PROFILES IN ASSOCIATION WITH IBM – ENVIRONMENTAL CHEMIST MILENA BONIOLO

How the humble banana peel could be the key to cleaning up water in Brazil

Water pollution is a big deal in Brazil. Around 50 per cent of the population has no access to a reliable, clean water supply. For large coastal cities such as São Paulo and Rio de Janeiro, which find their water supply contaminated by unregulated residential and industrial sewage further upstream, it is getting worse. Despite a US$400 million clean-up effort, in 2007 the Tietê River, which runs through São Paulo, had a dissolved oxygen level of 0mg per litre – that's back down to its 1990 levels, and no joke for the city's 11 million residents. Plus, there are links with savings further down the line: $1 spent on sanitation is $4 to $5 saved in healthcare.

Milena Boniolo, a PhD student at São Carlos, studies environmental contaminants. She found that one way to clean heavy metals (lead, mercury, nickel, cadmium etc) and uranium from the water supply happened to be in every market and restaurant in São Paulo: banana peel. Powdered and mixed with the waste water, it is able to bind and concentrate huge amounts of heavy metals through a process called biosorption (the negatively charged molecules on the surface of the banana peel attract the positively charged heavy metals).

Other forms of biosorption use seaweeds, but for Boniolo the banana peel is perfect – for starters there's no shortage of the stuff. The city's fast-food restaurants alone discard four tonnes of banana peel every week, and 30 per cent of the annual production ends up as waste.

Cheap, readily available and sustainable, it is also very effective. After just 40 minutes of treatment, at least 65 per cent of the pollutants are removed. There's something very neat about the idea that our own waste products can be used to clean our water supply. The challenge now is to move it from the laboratory to a pilot scheme.

The other side of Boniolo's research concentrates on analysing another type of water contaminants that are consumed by humans and animals alike: hormones and pharmaceuticals. Some of these are endocrine disruptors that, even in tiny quantities, can affect reproductive systems and, crucially, often stay in water supplies even after treatment. *Find out more about Milena Boniolo by visiting her profile at ted.com/profiles/view/id/373425*

PHOTOGRAPHY: JAMES DUNCAN DAVIDSON/TED

REAL WAYS IBM IS HELPING WATER PURITY AND SUPPLY

Though it is a worldwide resource, water is treated as a regional issue. Whether you have a big problem or not depends entirely on where you live. With advances in technology – sophisticated sensor networks, smart meters, deep computing and analytics – we can be smarter about how we manage our planet's water. We can monitor, measure and analyse entire water ecosystems, from rivers and reservoirs to the pumps and pipes in our homes. IBM's Advanced Water Management experts and the Nature Conservancy are running advanced simulations to help visualise the different effects of water use in the Amazon basin. Go to *ibm.com/smarterplanet* to find out more.

FOR WHOM THE BELL TOLLS

THE SECOND IN OUR SERIES OF TED FELLOWS PROFILES IN ASSOCIATION WITH IBM – INSTALLATION ARTIST DAVID GURMAN

Real-time data feeds connect physical objects to current events in David Gurman's mechanised art

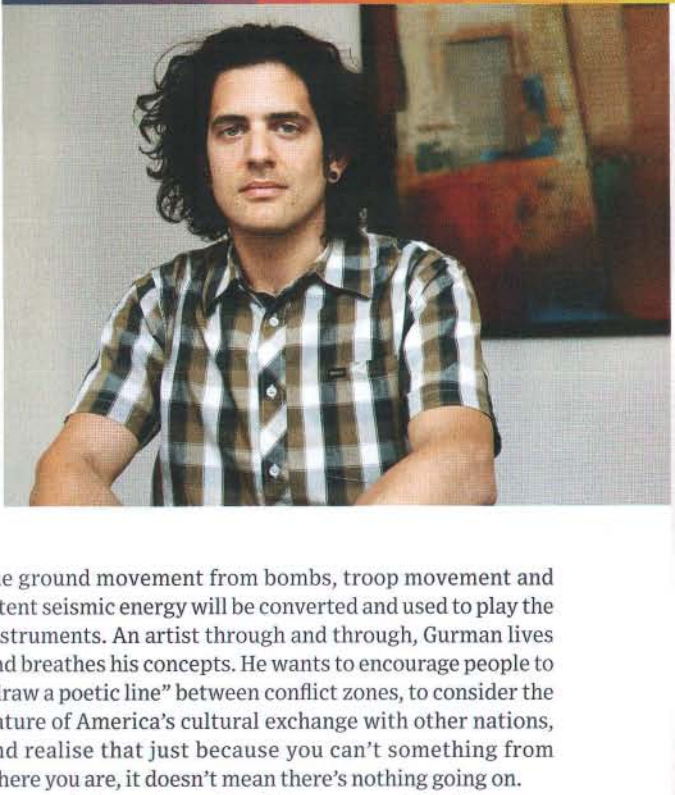
The best art is more than just aesthetically appealing. It is arresting, intriguing and thought provoking, going way beyond the canvas. For David Gurman, the key is to make the remote immediate – to put us in contact, at some level, with events happening on the other side of the world.

War is the focus for much of his work. In one of the most impressive, *The Nicholas Shadow*, he created a space in a chapel of St Ignatius Church in San Francisco. Gurman linked a church bell to a live webstream from iraqbodycount.org. Every hour it would automatically trigger the bell to toll the number of civilian deaths in Iraq that day. In the 66 days of its installation in 2009, it rang 906 times. On April 24 of that year, 71 people were killed by female suicide bombers in Kadhimya, Baghdad. The bell rang continuously for 18 minutes.

It didn't matter if you were priest or clergy, dove or hawk: "the tolling of the bell became a real focus for meditation, for thought," says Gurman. This union of the mechanical with the real has a remarkable ability to cut through the noise of the rat race, to form a tangible link with events elsewhere and give them immediate gravity.

His current project, *Pax Americana*, will connect Afghanistan, Iran, Iraq, Israel and the United States. In it, a piano, viola, cello, bassoon and kettle drum will be linked to a real-time seismic stream from each nation. The idea is that the ground movement from bombs, troop movement and latent seismic energy will be converted and used to play the instruments. An artist through and through, Gurman lives and breathes his concepts. He wants to encourage people to "draw a poetic line" between conflict zones, to consider the nature of America's cultural exchange with other nations, and realise that just because you can't something from where you are, it doesn't mean there's nothing going on.

For more information on David Gurman, go to davidgurman.com. *For more about the TED Fellows, go to* ted.com/fellows



PHOTOGRAPHY: JAMES DUNCAN DAVIDSON/TED

HOW IBM'S SMARTER PLANET MAKES SENSE OF GLOBAL DATA

The planet has always generated an enormous amount of data, but we couldn't hear it or see it, let alone capture it. Now technology exists to capture and process all this raw data and turn it into not just organised information, or even knowledge, but actual *intelligence*. It reveals everything from large and systemic patterns to the tiniest detail, from the environment to a factory, and from cities to the billions of individuals using social media. These individuals tell us what they think, what they like and want, and what they're witnessing in real time. But on its own, the data is useless. The actionable insights that the data can reveal, though, are priceless. *Go to ibm.com/smarterplanet to find out more*

fetish

2010 GEAR SPECIAL

OBJECTS OF DESIRE 11.10
WIRED'S ANNUAL
TECHNOLOGY WISHLIST

- COMPUTING
- VISION
- HOME
- IMAGE
- TIME
- TOYS
- TRANSPORT
- SOUND

BMW takes racing tech to the road. *See page 103*

PHOTOGRAPHY: WILSON HENNESSY; ROGER STILLMAN.

USB CONTROL

1 Seven-port hub with switches

If you're a fan of USB novelties or if you only want your bus-powered hard disk on when you actually require it, you need a smarter USB hub. This model lets you turn off your USB Christmas tree out of season, and each port has current-detection circuitry to prevent damage from electrical surges.

$19 (£12) thinkgeek.com

THE MICRO NETBOOK

2 Toshiba AC100

The AC100 is a tiny netbook, 26mm wide, 21mm thick and 870g. It has a ten-inch screen, and runs Google's Android 2.1 smartphone OS as its operating system. Not only does it start up almost instantly, but Toshiba claims the advanced power management will give more than seven days' standby battery life.

£250 toshiba.co.uk

SEAMLESS STORAGE

3 Hitachi LifeStudio Plus

The LifeStudio base station contains a 320GB portable hard disk and 4GB USB key. The software pulls in photos and videos from your computer and web storage sites such as Flickr, and displays them on a 3D "wall". You can then select the content and which storage device to use for automatic backup.

£70 (320GB drive) lifestudio.com

1 / COMPUTING

HARDWARE FOR THE WIRED HOME

DESKTOP 3D PRINTING

4 Objet Alaris30 3D printer

Objet's PolyJet technology works like 2D inkjet printing. When a 3D CAD drawing is sent to the printer, photopolymer materials jet out in 28-micron layers until the product is created. These then harden under UV rays in the out tray, making even multiple moving parts possible in a single print.

€19,900 (£16,240) objet.com

ALTERNATIVE TRACKPAD

5 Swiftpoint Tiny Mouse

The space-efficient 42mm x 57mm Swiftpoint is designed to be used on the area just below your laptop's keyboard, so you don't need a desk. You grip the Tiny Mouse like a pen, and Swiftpoint says it is 30-40 per cent more accurate than a trackpad. The mouse is charged from your laptop via USB.

£67 futuremouse.com

THE SMARTER PHONE

6 RIM BlackBerry Torch

The Torch is RIM's first smartphone with Qwerty keyboard and multi-touch display. Along with a 624MHz processor and 480- x 360-pixel touchscreen, it also has a new operating system. BlackBerry 6 reformats web content as you zoom, by wrapping text columns around images while maintaining website layout.

£480 blackberry.com/uk

GAMING POWERHOUSE

7 Acer Aspire Predator AG7750

The casework of Acer's premium gaming PC opens for access to the tech within. Its quad-core 2.8GHz Intel Core i7-930 processor, NVIDIA GeForce GTX 470 graphics card and 6GB RAM are enough for the latest games at high resolutions, and you have a terabyte of storage for extra downloadable content.

£1,600 acer.co.uk

The Predator supports NVIDIA'S 3D Vision (if you add a 3D monitor)

SLENDER SCREEN

1 Samsung UE55C9000 3D TV

By putting the display-illuminating LEDs around the edge rather than behind the screen, Samsung has managed to make its 55-inch TV less than 8mm thick. It can deliver full HD 3D images using the bundled active-shutter glasses, and a three-inch screen on the remote allows you to watch two channels at once.

£6,000 www.samsung.co.uk

The UE55C9000 comes with built-in Freeview HD and Wi-Fi capability

PHOTOGRAPHY: WILSON HENNESSY; ROGER STILLMAN

WATCH FROM ANYWHERE

2 Monsoon Vulkano Deluxe

The Vulkano pulls all your TV channels and digital content together on to your TV, mobile phone, computer or iPad. By connecting to your set-top box, TV and home network, it can stream live, recorded or downloaded video over a Wi-Fi or 3G connection to your mobile devices, regardless of where you are.

$280 (£180) myvulkano.com

THE NEW DISPLAY TECH

3 LG 15EL9500 OLED TV

LG's 15-inch HDTV is the largest organic LED screen on the market. OLED screens don't need a backlight, so they can be paper-thin – this one is only 3.2mm thick. Also, as the LEDs emit light directly, rather than through a filter, OLED screens can be brighter and have higher contrast than LCDs.

£1,511 lg.com

MEDIA SAVVY IN-CAR FUN

4 Pioneer AVH-P5200DVD

Perfect for traffic jams, the AVH-5200DVD can play any media device you throw at it – MP3 player, USB drive, SD card, DVD or CD – on its seven-inch motorised fold-out screen. Different zones allow front passengers to play music from one source while those in the rear watch a film on optional extra screens.

£550 pioneer.co.uk

2 / VISION

CHANGING THE WAY WE WATCH

BIG IMAGE, SMALL ROOM

5 Sanyo PDG-DWL2500

Thanks to the world's shortest throw ratio, which defines how far away a projector can be from a screen for a certain picture width, this 3D projector can shine an 80-inch image on a surface from just 32cm away. The ultra-short-focus optics make it ideal for rear projection, office and classroom.

£906 sanyo.co.uk

UNIVERSAL 3D SPECS

6 Monster Vision 3D glasses

There is no standard for home 3D glasses, so your Panasonic specs only work with your friend's Samsung TV if you wear them upside-down. Instead, get your mates to buy Monster 3D specs – they work with any 3D TV and, according to the makers, are less likely to lose 3D sync than standard glasses.

£165 monstercable.com

HIGH-POWER AUDIO HUB

7 Marantz SR7005

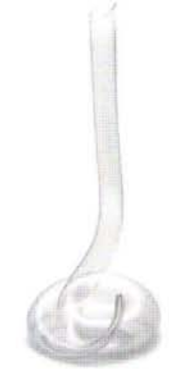
As your home-cinema hub, the SR7005 has inputs for up to six HDMI 1.4 devices including 3D sources. Its seven 125W amplifiers deliver the latest HD audio formats, and you can calibrate the amp to suit the acoustics of your room automatically with the included Audyssey mic.

£1,399 marantz.eu

BREAKFAST-BAR BARISTA
1 Gaggia Accademia

Gaggia's beans-to-cup machine lets you control coffee strength and the amount of milk froth using digital controls, and the machine memorises your favourite settings to reproduce your ideal coffee in a single button press. There are separate boilers for steam and espresso, so you never burn your Blue Mountain.

£1,761 cafegaggia.co.uk



THE PERFECT WINE PREP
2 Riedel Eve decanter

Wine experts recommend decanting two hours prior to serving to allow the vino to breathe. The Eve decanter makes your drink gurgle through a looped tube, taking in oxygen all the time as you revolve it. This effectively double-decants your wine, so you don't have to wait so long before drinking it.

£375 riedel.co.uk

CREATE A CLEAN AIR BUBBLE
3 Humanair air purifier

As your personal desktop air filter, the Humanair's ozone-free operation creates a bubble around your desk free of dust, pollutants and biological contaminants. It is claimed to remove 99 per cent of contaminants from the air, is almost silent and uses just 22 Watts of power – less than a desk lamp.

$399 (£257) humanscale.com

3/ HOME

FUTURISTIC CREATURE COMFORTS

DATA-BASED COOKERY
4 Samsung OmniPro

Samsung's latest microwave oven has sensors that measure the weight and water content of the food placed inside. The user simply selects the type of food, be it red meat or a ready meal, and the oven then calculates the cooking time and temperature, monitoring the entire process until it's ready.

£400 samsung.co.uk

CUTTING IT FINE
5 Edgeware Mandoline Slicer

For precision food preparation, mandolines offer chefs the thinnest and most consistent slicing. Edgeware's Mandoline Slicer uses five interchangeable surgical-grade blades made of German steel (and comes with a case to store them in), cutting slices from a thickness of 9.5mm to that of paper.

$180 (£116) edgewareproducts.com

SMART COOKER
6 Miele KM5993 Induction Hob

Miele's induction hobs and cooker hoods can communicate with each other over Ethernet, via the Con@ctivity sytem. It means that when you begin cooking, the hood knows when to unfold and begin extracting. The hob also detects the size of the pan placed on it, and only heats where it needs to.

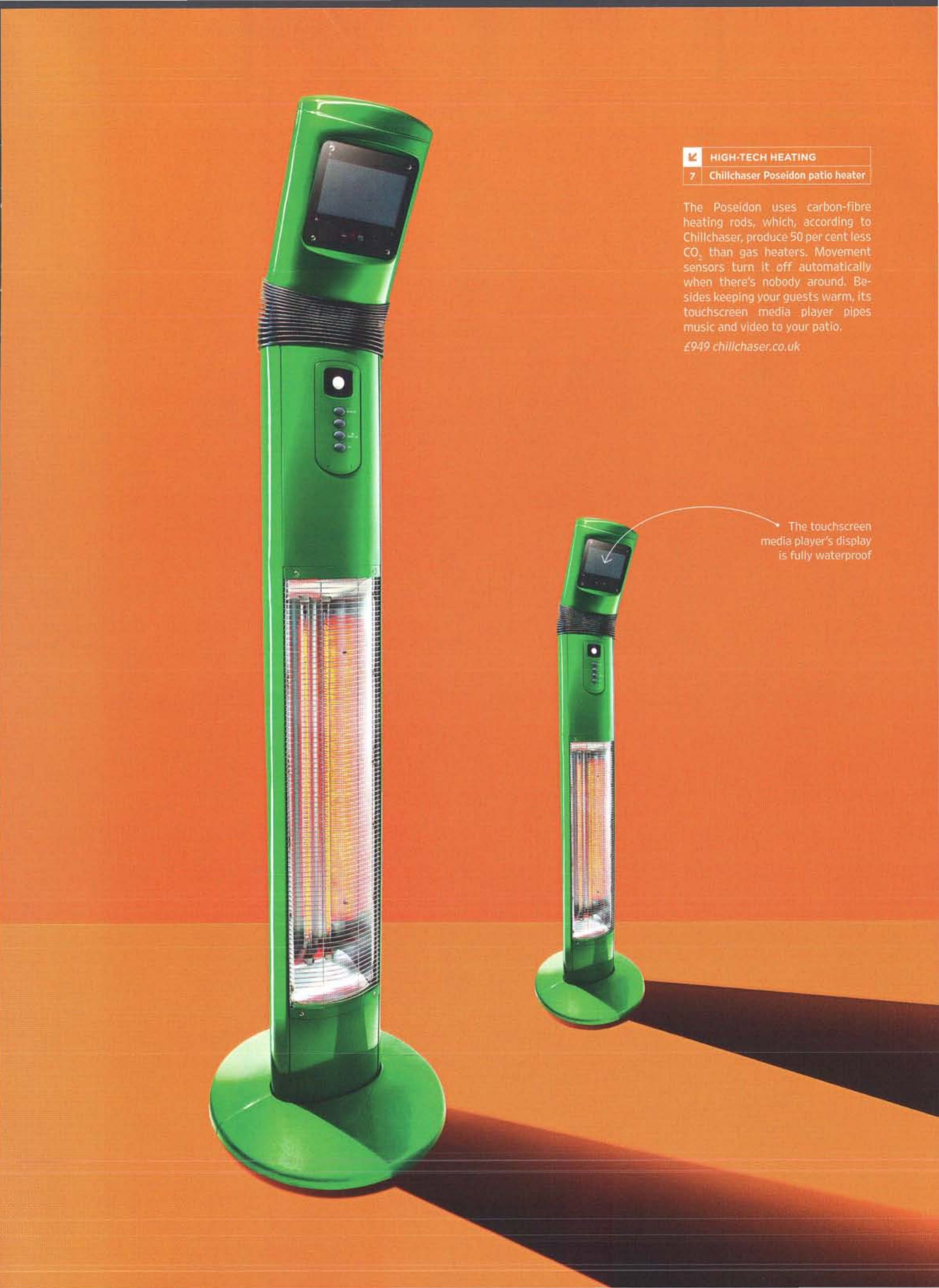
£2,089 miele.co.uk

HIGH-TECH HEATING

7 Chillchaser Poseidon patio heater

The Poseidon uses carbon-fibre heating rods, which, according to Chillchaser, produce 50 per cent less CO_2 than gas heaters. Movement sensors turn it off automatically when there's nobody around. Besides keeping your guests warm, its touchscreen media player pipes music and video to your patio.

£949 chillchaser.co.uk



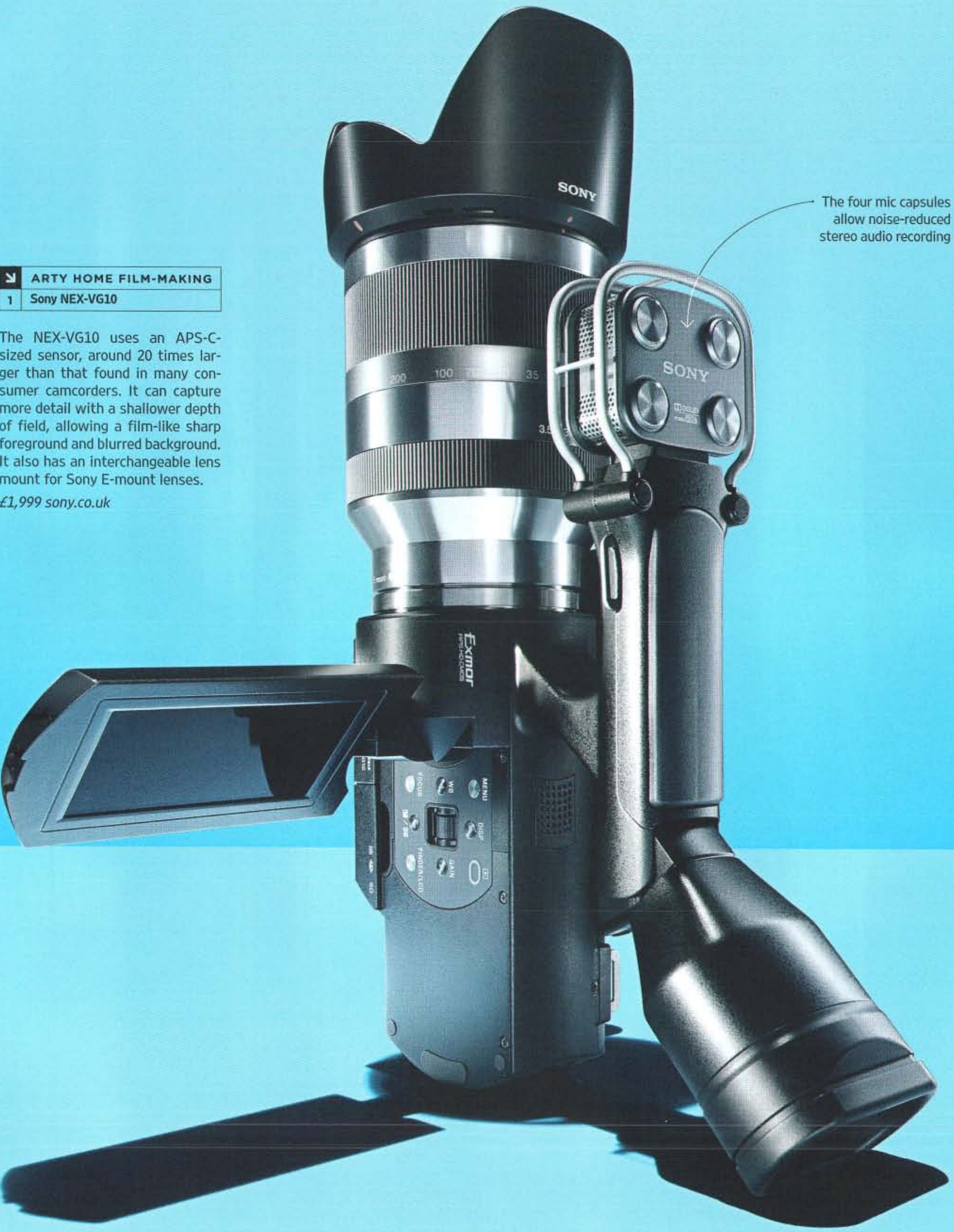
The touchscreen media player's display is fully waterproof

ARTY HOME FILM-MAKING

1 Sony NEX-VG10

The NEX-VG10 uses an APS-C-sized sensor, around 20 times larger than that found in many consumer camcorders. It can capture more detail with a shallower depth of field, allowing a film-like sharp foreground and blurred background. It also has an interchangeable lens mount for Sony E-mount lenses.

£1,999 sony.co.uk



The four mic capsules allow noise-reduced stereo audio recording

FULL-CIRCLE SHOOTING

2 Lomo Panoramic 360° camera

The Lomo captures 360-degree images on 35mm film. Pull the cord and it revolves fully in the split second that the shutter is open, taking in the entire scene in one sweep. It can take eight wide-angle photos on a regular 36-exposure roll, and a built-in spirit level means you always get the horizon lined up.

£100 firebox.com

DURABLE NIGHT-VISION

3 Y-cam Bullet camera

The footage from internet-protocol cameras can be viewed remotely online, making them ideal for surveillance. The Bullet's casing protects its electronics from whatever the elements can throw at it, and a ring of 12 infrared LEDs allow 24-hour 640 x 480 video capture on to a MicroSD card.

£298 y-cam.com

LOCATE YOUR MEMORIES

4 Leica V-Lux 20

Leica's first compact super-zoom camera uses GPS to tag each photograph with embedded information about precisely where it was taken. It's aimed at globetrotters who like to plot their experiences on Google Earth. The camera also features a 12x zoom, 12.1-megapixel sensor and 720p video.

£495 leica-camera.co.uk

4 / IMAGE

PRECISION PICTURES AND PLAYBACK

EXTREME DATA-LOGGING

5 Oregon Scientific ATC9K HD

Not just an action cam. Along with recording high-def video on to MicroSD memory cards, the helmet- or handlebar-mounted camera also has a G-sensor for measuring gravity, acceleration and deceleration, and a GPS tracker to tag the location. Review your extreme-ride data with the included software.

£249 oregonscientific.co.uk

POCKET-SIZED 3D

6 Fujifilm FinePix W3 Real 3D

Fujifilm's W1 brought us 3D still photography; now the W3 adds 3D HD video recording. Its two lenses and sensors can capture left- and right-eye images, which can then be viewed on a stereoscopic 3D TV with active shutter glasses. You can watch without the 3D glasses on the camera's own display.

£400 fujifilm.co.uk

HUMAN-EYE CAMCORDER

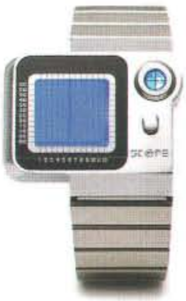
7 Panasonic HDC-SDT750 3D

The HDC-SDT750's 3D lens adapter lets it capture side-by-side images, which are offset to mimic the different images captured by human eyes. These play back as alternate frames on a 3D TV, and active-shutter glasses only show you the right frame at the right time, fooling your brain into seeing 3D images.

£1,345 panasonic.co.uk

5 / WATCHES

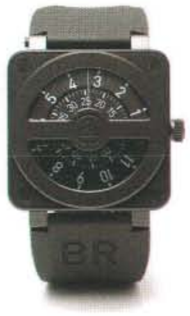
TECHNOLOGY MEETS TIMEKEEPING



RETRO SCI-FI TIMEPIECE
1 Seahope Scope

The Scope is inspired by Deckard's photograph-enhancement machine in *Blade Runner*. The x-axis shows hours and the y-axis minutes in increments of five – the point at which they cross reveals the correct time. One-minute increments are shown by the sub-screen on the right. Now resist saying "enhance".

¥23,100 (£174) seahope.com



DIRECTION-INSPIRED TIME
2 Bell & Ross BR01-92 Compass

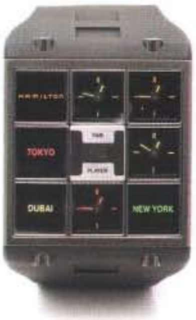
The Compass takes its cues from an aircraft dashboard – the navigation compass in a cockpit makes it easy to take a reading at a glance, and the B&R Compass uses the same principle. Instead of hands, two lightweight graduated discs turn clockwise, and the exact time is indicated by a static needle.

£3,400 bellross.com

THE WEATHER WATCH
3 Suunto Core Extreme Edition

The latest version of Suunto's outdoor wristwatch has an automatic altimeter/barometer switch. When it senses you're climbing, it records changes in elevation, but when you're stationary it records any shift in barometric pressure as climatic change rather than height above sea level.

£225 suunto.com



WORLD-TIME PUZZLE
4 Hamilton Time Player

The face of this titanium watch is made up of nine sliding tiles that you can move around like a puzzle. "Hamilton" is the current time, while colour-coded sub-dials show the hour in New York, Tokyo or Dubai. When one of the three time zones is in the centre you can adjust the time with the two crowns.

£2,000 hamiltonwatch.com

THE RAF PILOT'S WATCH
5 Casio G-Shock GW-3000B-1AER

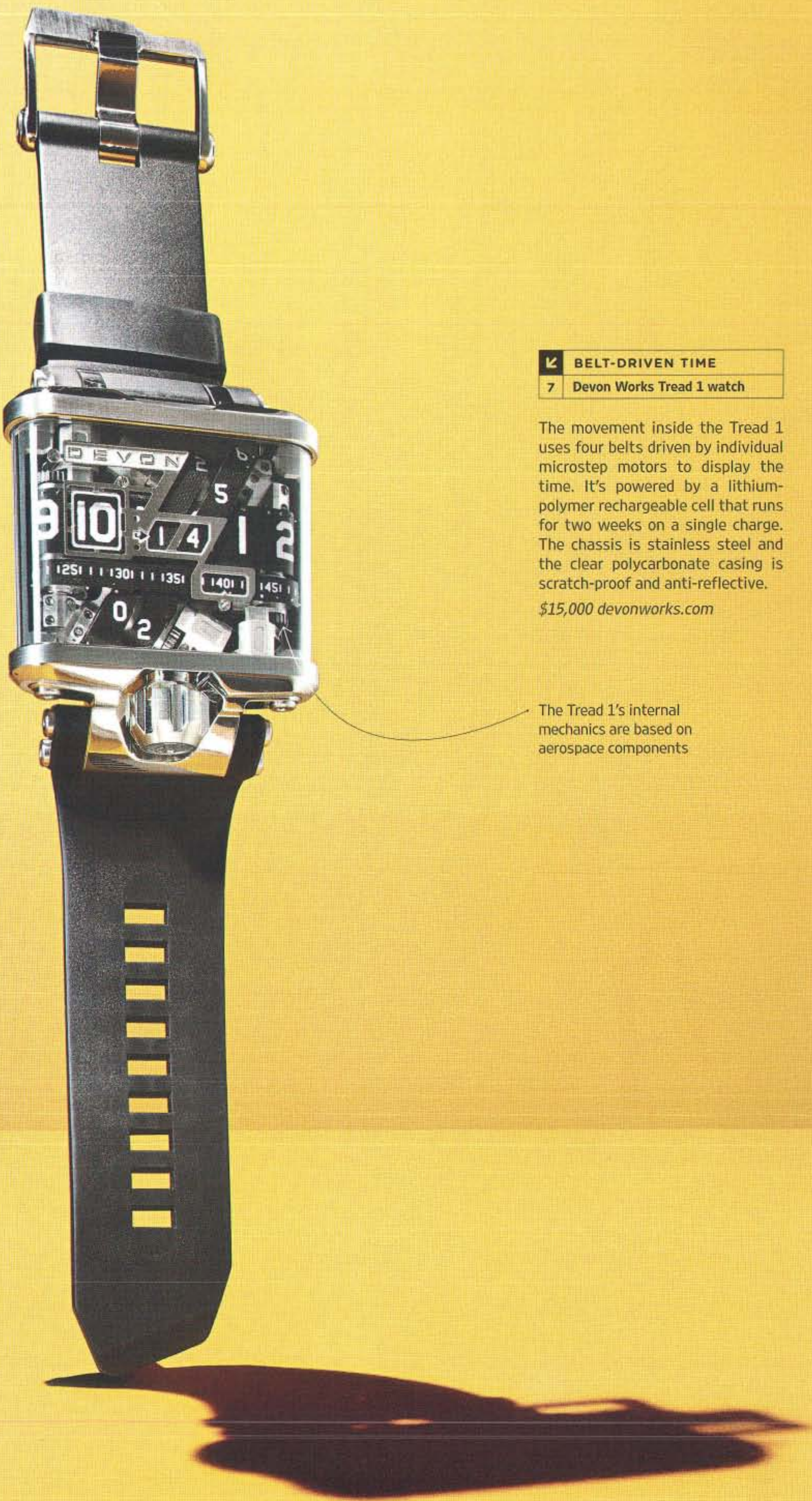
The top two pilots graduating from the RAF Valley combat-training station in Anglesey are given an engraved GW-3000B to go with their wings. The body of the watch is ion-plated steel and the movement is radio-controlled for accuracy. The face layout is designed to be read instantly in the cockpit.

£162 casio.co.uk

DESIGNED FOR YACHTING
6 Tissot Sailing Touch

Tapping the crystal face of this touchscreen watch makes it scroll through a range of nautical functions, such as tide times at your destination, compass and regatta timer. The watch also measures atmospheric conditions and displays a histogram showing pressure change over the preceding six hours.

£500 tissot.ch



BELT-DRIVEN TIME

7 Devon Works Tread 1 watch

The movement inside the Tread 1 uses four belts driven by individual microstep motors to display the time. It's powered by a lithium-polymer rechargeable cell that runs for two weeks on a single charge. The chassis is stainless steel and the clear polycarbonate casing is scratch-proof and anti-reflective.

$15,000 devonworks.com

The Tread 1's internal mechanics are based on aerospace components

PHOTOGRAPHY: WILSON HENNESSY;
ROGER STILLMAN,

The Roboscooper can also speak and make noises

A HELPING ROBOT HAND

1 WowWee Roboscooper robot

WowWee's most helpful robot yet uses proximity sensors to locate, collect and cart away obstacles. In autonomous mode, Roboscooper will trundle around on six all-terrain wheels and clear up your discarded items. In remote-control mode you can command it to swat them away with a rapid arm-movement.

$70 (£45) wowwee.com

PHOTOGRAPHY: WILSON HENNESSY; ROGER STILLMAN.

↗ MODELLING URBAN DECAY

2 | Hornby Graffiti Milk Wagon

Has broken Britain gone collectible? The attention to detail in Hornby's rolling stock now stretches to realistic graffiti applied over the weathered paintwork. In all respects this OO-scale model is an exact replica of a 90s-era milk wagon, complete with tags copied from examples of real marker-pen scribblings.

£10 hornby.com

↗ EDUCATIONAL GAMING

3 | Leapster Explorer

The Explorer is a touchscreen handheld console with an educational focus. Games range from a mix of action and education to pure learning – you can even download ebooks. The games' difficulty levels adjust to the speed of progress, keeping fast learners challenged without discouraging others.

£60 leapfrog.com

↗ IT'S ONLY IROCK 'N' ROLL

4 | Fingerist

The Fingerist transforms your iPhone or iPod Touch into a touchscreen guitar. Slot your handset into the chassis, then rock out through the integrated speaker. There's also an XLR output that plugs into a proper guitar amp. You will need a guitar app to go with it – we recommend *iShred* (£2.99).

$140 (£90) evenno.com

6 / TOYS

MAKING PLAYTIME SMARTER

↗ YOUR SPY IN THE SKY

5 | Air Hogs Hawk Eye

The Hawk Eye is the cheapest UAV you can buy. Its camera can take hundreds of photos or five minutes of video, and you can rework the results into airborne movies with the free video editor. Stabilising rotors make your videos wobble-free. Uses suggested on the website include terrorising your dog.

£64 airhogs.com

↗ TINY RETRO ROBOT

6 | Senario Zibits Mini Robots

Shox is just one of 12 collectible 50s-inspired radio-controlled robots made by Senario. The 7.5cm toy moves backwards and forwards on one powered and two stabilising wheels, and then spins through 360 degrees to steer. Each mini robot comes with its own sci-fi props to chase around your desk.

£15 senario.com

↗ SCUTTLING BUG-BOT

7 | Hexbug Ant

The latest and fastest member of the Hexbug mini-robot family propels itself on six wheels, each of which is shaped like three rotating feet. Wire antennae at both the front and rear trigger a reversal in direction when they touch an obstacle, so the ant's legs remain in motion until the battery dies.

£12 hexbug.com

LIGHTWEIGHT SUPERCAR

1 Arash AF-10

Arash Farboud has been perfecting his streamlined AF-10 supercar in Cambridge since 2005. The car's lightweight carbon-fibre honeycomb chassis and bodywork keep the kerb weight down to around 1,200kg, meaning its 550bhp seven-litre Corvette Z06 V8 should be able to propel it to around 200mph.

From £320,000 arashcars.com

SLICK HYBRID CYCLING

2 Gocycle Black Edition

At only 16.2kg, the latest edition of Gocycle's electric hybrid is lighter than its predecessors and also has a steeper head and seat angle. This provides for more responsive and aggressive handling. It's also now available with a 250W motor – which gives it a range of up to 30km at a speed of around 15mph.

£1,800 gocycle.com

A NEW DESIGN CLASSIC

3 Playsam Saab Roadster

Playsam has made the steering wheel of its 94cm-long pedal car from wood and aluminium, just like the real Saab it is based on – the original 92001 prototype from 1946. This was an aerodynamic coupé, and the resulting toy's streamlined shape presents no sharp edges for children to hurt themselves on.

£225 playsam.com

7 / TRANSPORT

FROM A TO B, VIA DESIGN INNOVATION

F1-INSPIRED WHEELCHAIR

4 Trekinetic K-2 wheelchair

This hi-tech chair's design is inspired by F1 cars. The carbon-fibre seat is a stressed member which supports the wheels, so doing away with a separate chassis. The location of the larger wheels at the front helps with rough terrain – there are no small wheels to dig in and stop forward momentum.

£2,595 trekinetic.co.uk

PEDAL ON THE WAVES

5 Nauticraft Escapade boat

Thanks to its heavily ballasted keel and buoyant hull, this pedal-boat is able to navigate the notoriously choppy waters of the Channel. It draws less than 60cm of water with three passengers aboard, so is equally at home in the shallows. Its twin 40cm propellers can achieve a hull speed of over 5mph (4.5kts).

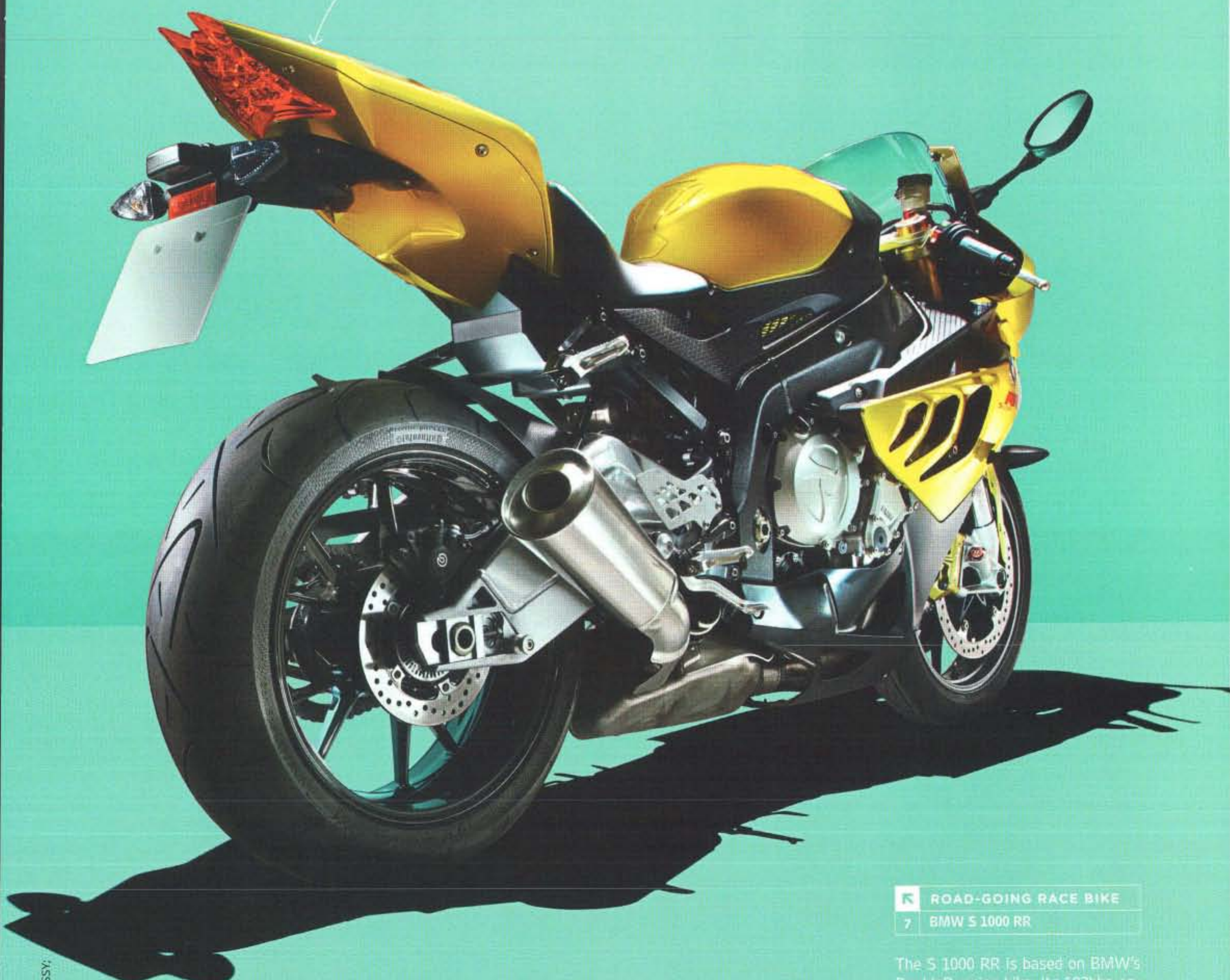
£2,500 hammacher.com

CHAMPION TRIATHLETE

6 Trek Speed Concept 9.8

Trek claims the Speed Concept is the fastest triathlon bike on the market. Much of this is down to aerodynamics – the cables, brakes and electronics are integrated into the bike's shape to cut down on drag. It's designed to slice the air regardless of its direction, in order to reduce the effect of crosswinds.

£6,000 trekbikes.com



The production bike keeps the factory model's tail-up design

ROAD-GOING RACE BIKE

7 BMW S 1000 RR

The S 1000 RR is based on BMW's DoubleR racing bike. Its 193bhp engine gives it a power-to-weight ratio of 0.95bhp/kg and there are throttle settings including "Rain", "Slick" and "Race". Torque adjusts dynamically according to grip, ensuring you always get optimum traction when coming out of any corners.

From £11,490 bmw-motorrad.co.uk

PHOTOGRAPHY: WILSON HENNESSY; ROGER STILLMAN.

DUAL-FORMAT DISC

1 ***The Occurrence* CD/vinyl**

The Occurrence is Jeff Mills's story of a space walk, set to music. But what makes the Japanese import edition interesting is the format. The analogue/digital hybrid is a CD with a vinyl groove printed on the upper side – put it on your deck, with the supplied foam insert, to listen to bonus track "Markings".

£51 axisrecords.com

The CD has 23 tracks – to hear the 24th you need a record player

The Occurrence Jeff Mills
STEREO ℗&©2010 Axis Records XECD-9128
VinylDisc manufactured by optimal media production gmbh
optimal-online.de

PHOTOGRAPHY: WILSON HENNESSY; ROGER STILLMAN.

FUSS-FREE HEADPHONES

2 AIAIAI TMA-1

To make headphones for live mixing and general listening, AiAiAi contracted Danish design firm KiBiSi, which consulted some of the world's top DJs. The result is a simple, branding-free, closed-cup design which weighs just 190g. The cups are coated in black rubber to protect the components inside.

1,400kr (£150) aiaiai.dk

CLEAN, CRISP SOUNDS

3 Philips Streamium MCI900

This hi-fi combines a CD/DVD player with web radio and network streaming, as well as playback from the integrated 160GB hard disk. The SoundSphere speakers have a novel way of protecting the tweeters' sound from coloration by the bass frequencies – they're held in the air by a rigid and sonically neutral arm.

£999 philips.co.uk

A ROCK-SOLID CD PLAYER

4 Metronome Technologie Kalista

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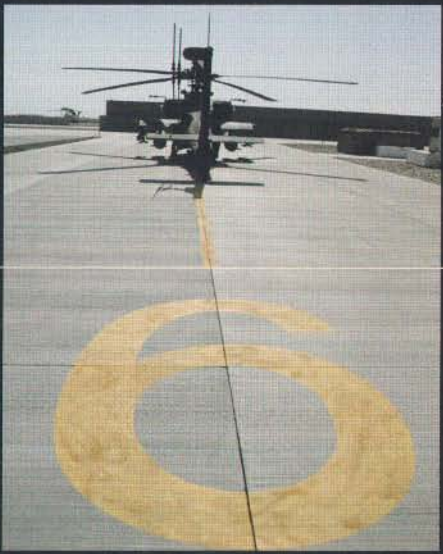

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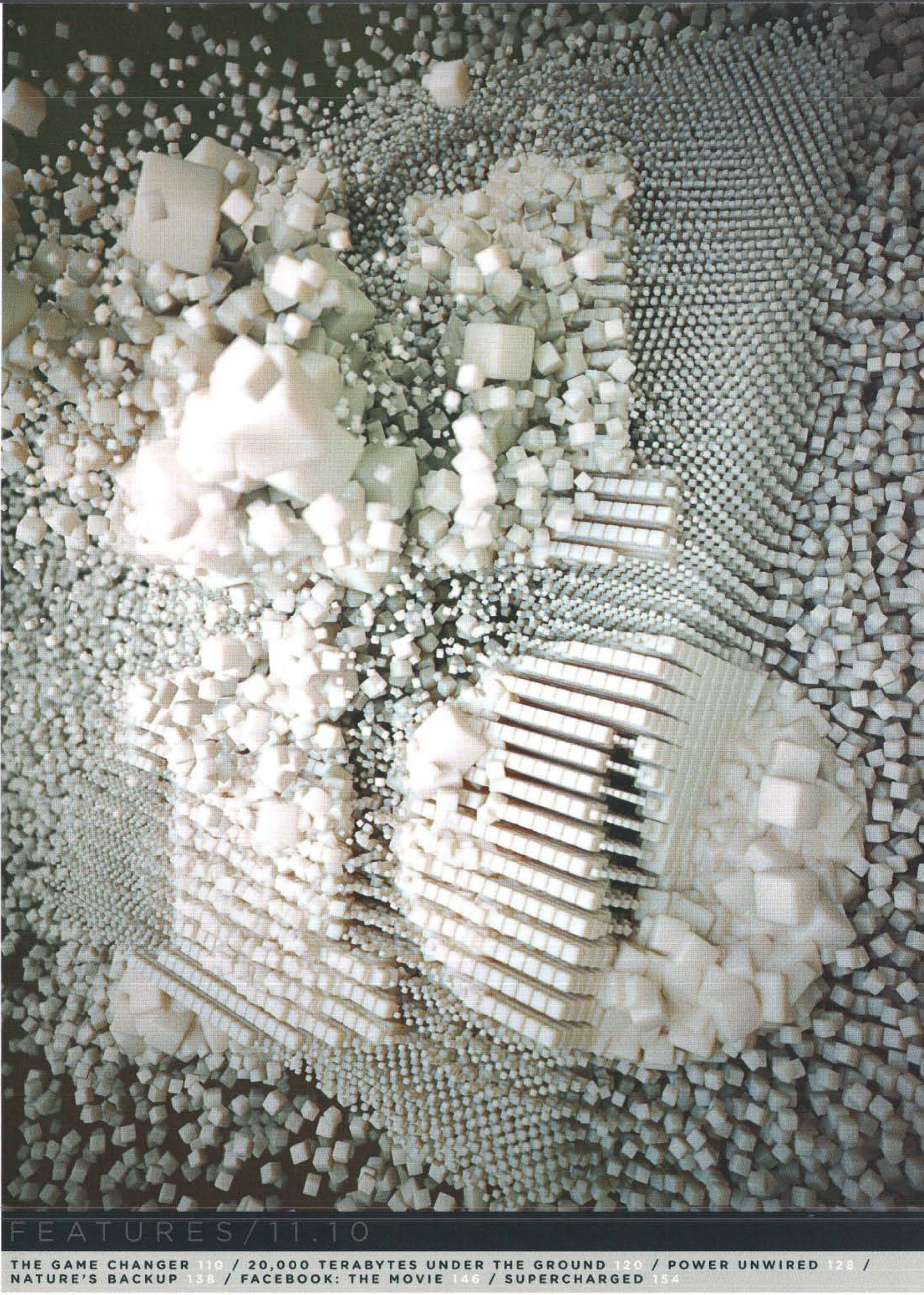

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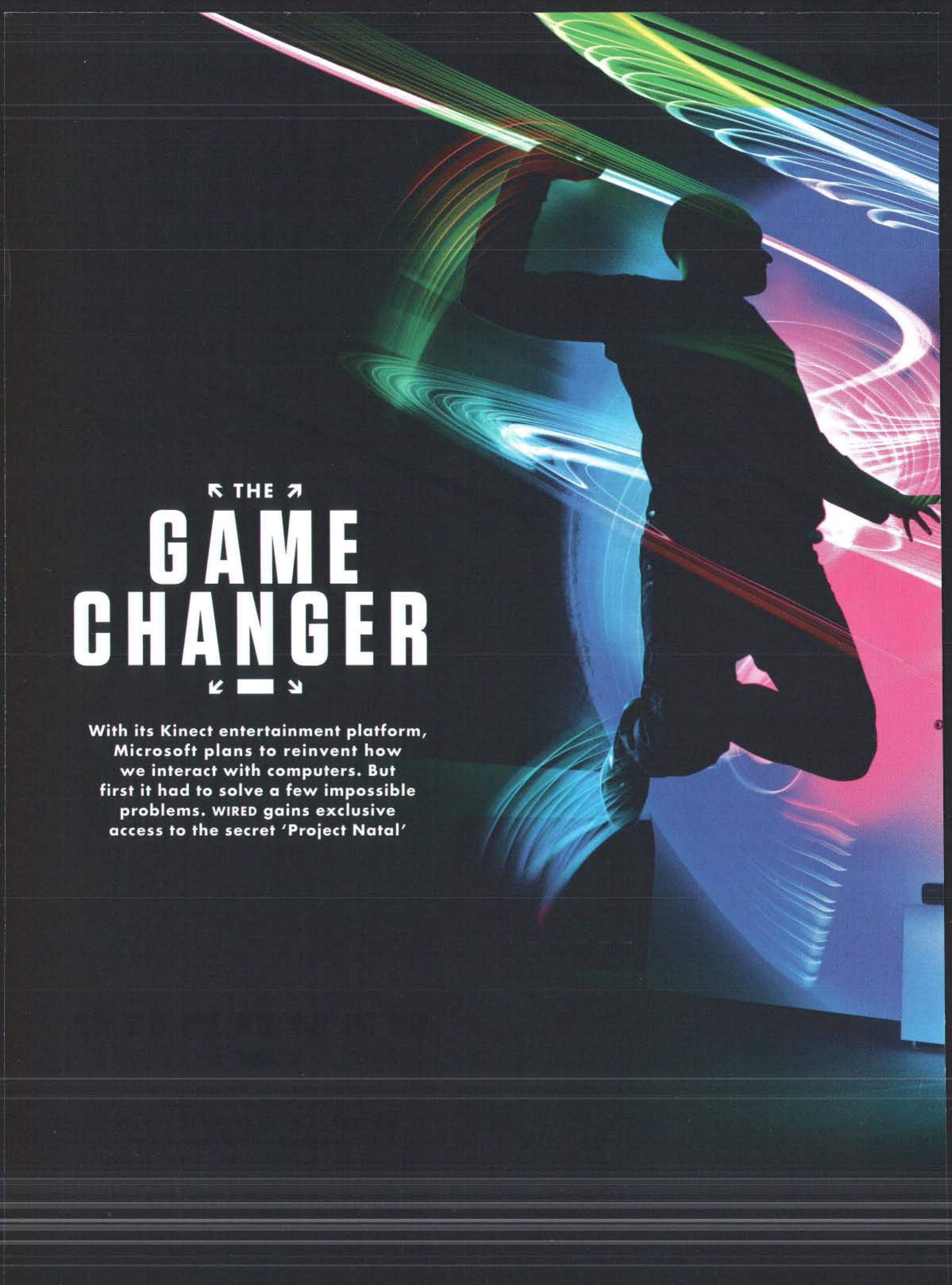


THE GAME CHANGER

With its Kinect entertainment platform, Microsoft plans to reinvent how we interact with computers. But first it had to solve a few impossible problems. WIRED gains exclusive access to the secret 'Project Natal'

KINECT WEB EXTRAS:
wired.co.uk/kinect

By David Rowan
Photography: Diver & Aguilar
Additional reporting: Terrence Russell

A jungle drumbeat stirs the air at Jefferson and Figueroa on a balmy June Sunday evening in downtown Los Angeles. The vast Galen Center, normally a University of Southern California sports arena, has tonight been transformed into a tropical forest, where 76 Cirque du Soleil acrobats, dancers and actors cavort as clowns, cavemen and a lovesick gorilla tying flowers into the hair of unsuspecting guests.

Microsoft's Xbox team has packed the hall tonight with VIPs such as Billy Crystal, Michael Cera, Rosario Dawson and Christina Hendricks, but all have been told to wear a white polyester poncho and to enter the auditorium through what appears to be a giant TV into a living-room where actors play family members. As the hour-long show begins, these families are winched up on their sofas to remain high above the audience, cheering as eight-metre projection screens, in total longer than an American football field, flash into life.

"Since the dawn of time, humanity's long journey has led us to countless discoveries," a solemn voice intones on the loudspeakers. "Yet with each leap forward for civilisation, more people have been left behind. But our quest has taken us to a completely new horizon." There is a pause. "History is about to be rewritten. This time human beings will be at the centre – and the machines will be the ones that adapt. After five million years of evolution, is it possible that the future of humanity is humanity itself?"

A four-metre puppet elephant slowly carries a boy towards a hill of rocks, from which emerges a giant 3D black-and-green Xbox logo that raises him higher. Green lights suddenly shine out from the poncho shoulderpads. "Hi, Alex," the voice booms. "Welcome home." The boy is lifted to a 12-metre-diameter rotating steel chamber bearing a screen on which he interacts with an avatar that copies his every movement. He then climbs inside into a rotating living-room where a family is enjoying a car-racing game they continue to play even when upside down.

As the screen reveals to Alex, this is "Kinect" – Microsoft's new motion-sensing system for the Xbox 360 that does away with the game controller in favour of the player's own body. The games demonstrated tonight – from bowling to yoga, river-rafting to road-racing – suggest only the beginnings of why Microsoft sees Kinect as its next multi-billion-dollar bet. It's not simply that it can track your body in real time, or recognise who in the room is playing, or respond to voice commands. It's that it can do all of these things at the same time – heralding what its creators call the era of NUI: natural user interface.

At the global media briefing next morning, Don Mattrick, senior VP for interactive entertainment, explains why this is about much more than gaming. "Kinect brings your living-room alive in a social and accessible way," he tells the Wiltern Theatre. "Interactive entertainment is the greatest form of all entertainment, and it should be open and approachable to as many people as possible. It is this belief that led us to remove the last barrier between you and the entertainment you love. By making *you* the controller, we will transform how you and your friends experience games and entertainment."

So as well demonstrations of *Kinect Sports* (from soccer to bowling), *Dance Central* (screen-based dance lessons) and *Kinectimals* (interaction with virtual pets), journalists are shown Laura, one of the Kinect engineers, videoconferencing headset-free with her twin sister Kristen in Texas – and she merely says, "Xbox end chat," when it's time to disconnect. Ron, another engineer, signs in to Kinect simply by waving, and then similarly waves the air to access Netflix, Facebook and Last.fm. "Xbox, play music," he says; then, "Xbox, pause." No remote control.

An hour later, Matt Barlow, marketing boss for Xbox 360 and Xbox Live, explains to WIRED the vast business opportunity ahead. "Gaming is a $48 billion business," he says. "The challenge is how you continue to grow. We have the capability to turn your living-room into a petting zoo, into a sports stadium – so our customer base is all those who have rejected gaming either because of the content or the controller. If you could say doubling, tripling, quadrupling the audience – I believe that. We're also talking about a hypersocial audience, predominantly female, who want to interact while playing."

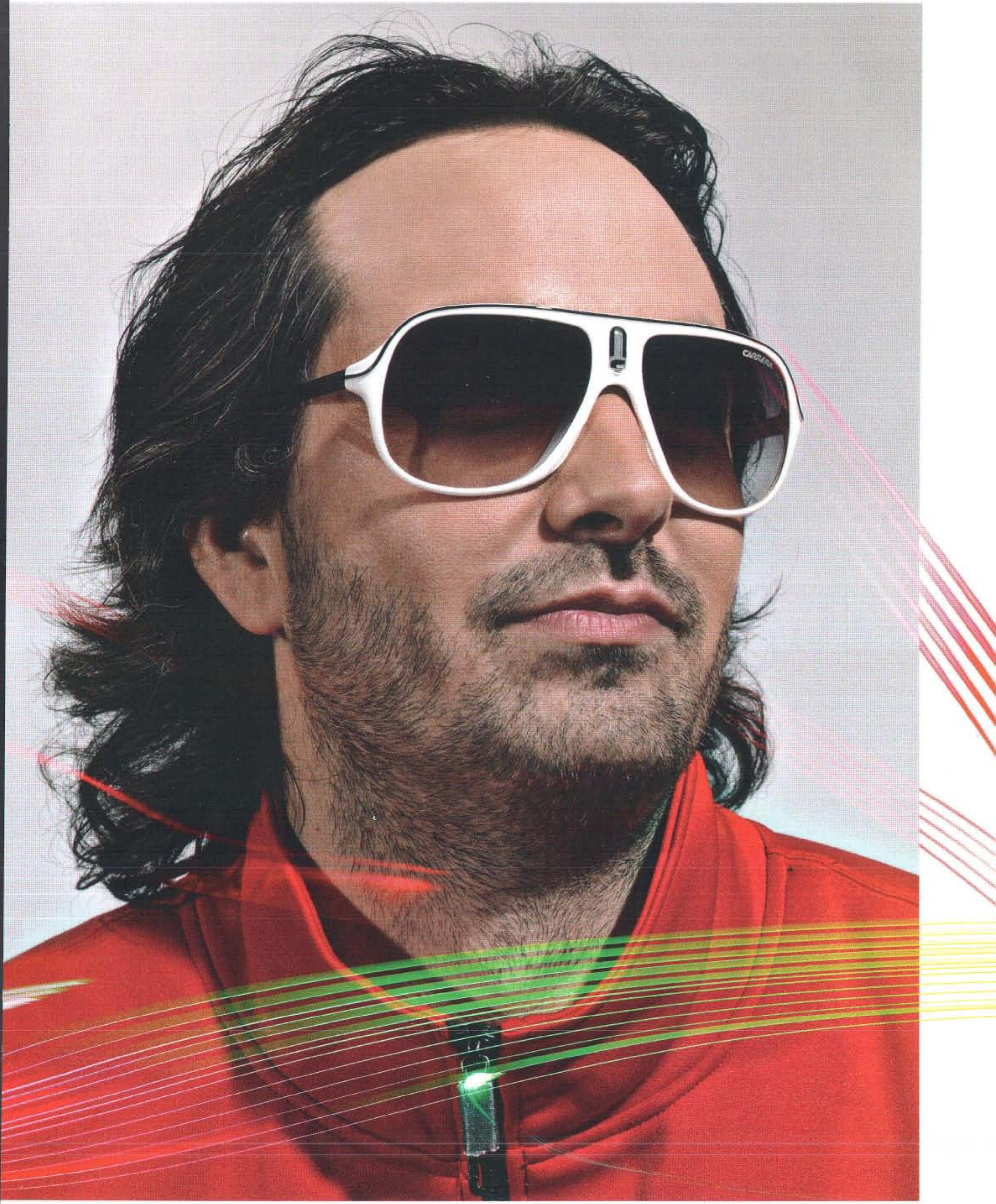
As other executives point out, this is about far more than gaming to Microsoft. "We believe the platform will move beyond the console," says Ben Kilgore, general manager of the Xbox platform. "Every kind of major Microsoft group in the company is evaluating Kinect. They're trying to understand what it means for those experiences."

* * *

By mid-2007, Don Mattrick, who runs Microsoft's interactive-entertainment business division in Redmond, Washington state, was demanding a new direction for the Xbox 360. "There has to be a fundamental reimagining of the way we interact," explained Marc Whitten, Xbox Live VP, in a strategy meeting. To be fair, Whitten – along with the rest of the senior executive team – wasn't certain what this meant in terms of hardware. Still, they compiled a cursory list of desired features: motion-tracking controls, facial recognition, speech recognition and backwards compatibility.

The problem wasn't vision. It was the task's sheer impossibility. Finding cameras that could map a living-room in 3D was easy. Getting one reliably to decode the flailing limbs and shouts of 40 million Xbox users was a whole other dream. To pull this off, the hardware would require a software "brain" capable of interpreting what the team calculated was a crushing 10^{23} spatial and aural variables at any given moment.

Previous spread: Kinect's central-London demo room. *Opposite*: Kudo Tsunoda, game visionary and the creative force behind Project Natal


CARRERA

And it would have to do this on the fly, with no perceptible on-screen lag.

Still, fragments of the solution did already seem in place. Microsoft Research's Beijing bureau had collected tomes on the successes (and failings) of facial-recognition technology. Redmond's speech-recognition software – which now ships in Windows 7 and the Ford Focus – had already been in development for decades. And Redmond's hardware engineers were busy creating exotic gyroscopic and accelerometer-based controller prototypes in anticipation of the coming shift. But it would take exhaustive research and testing before anyone could guess whether such a shift would be workable – or profitable.

As 2008 began, Mattrick made it known that he wanted to transform and expand Xbox 360 and allow users to experience gaming and entertainment in a different, more social way. Could his teams take depth sensors, multi-array microphones and RGB cameras and turn them into a consumer experience? The magic box would need to track people at 30 frames per second, recognise them, understand how they move, and incorporate voice recognition – and all in ways that could enhance the game experience.

There was just one problem: this hadn't yet been done anywhere in the world.

* * *

"The challenge was simple: we needed to get rid of the barrier. We needed to actually take a look at all the different ways we could get rid of the controller."

Alex Kipman, 31, the man tasked with implementing Mattrick's vision, speaks at a machine-gun's pace, and uses broad, sweeping hand gestures to illustrate his points. Kipman, from Natal in Brazil, has registered 16 patents since joining Microsoft in 2001. Now, as incubation director for Xbox 360, he got to choose a code name for his new task: Project Natal.

In jeans and brown T-shirt, he explains the incubation journey. The first task, he says in a Redmond conference room, was to research probabilistic machine learning: ways to train a computer to guess what you are going to do next.

His team, around 15 people, had been picked for their non-traditional skill sets. "I have artists, musicians, painters, researchers, engineers, people from Hollywood, CGI/FX supervisors from *The Matrix*. The idea being, let's have that diversity in thought, in creativity." Their brief, he says, was to "fail fast" – and also to be stupid. "Incubation is a business of stupidity. If we don't feel stupid, we're not pushing ourselves hard enough."

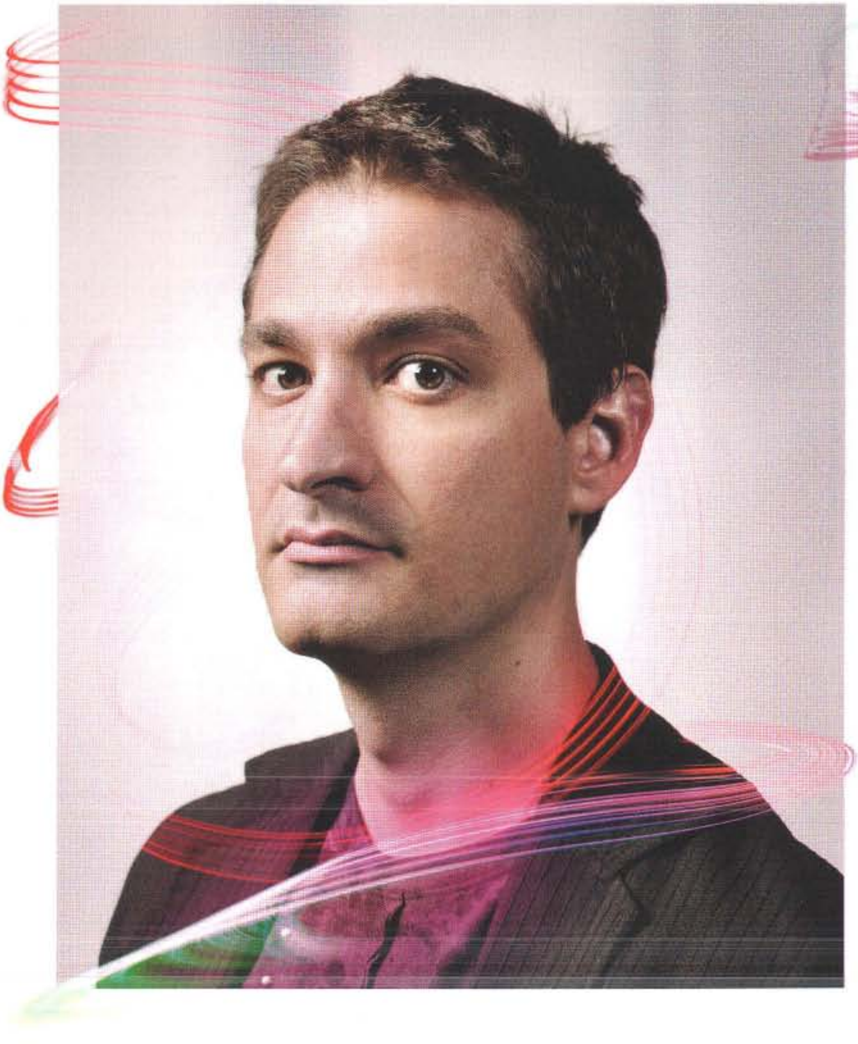
Some of the challenges involved were more straightforward than others. Speech recognition, for instance, had the benefit of years of Microsoft innovation. But recognising individuals from their faces and body shapes was harder. "It turns out that in the living-room, Darwin is against you," Kipman says. "People in the same household tend to be very alike. I call it identity recognition. *Facial* recognition doesn't work."

But adding body tracking to recognising humans and understanding their speech? Suddenly the machine had to cope with those 10^{23} possibilities. That, Kipman knew, was way beyond standard programming abilities: "It's not going to happen in this lifetime that any number of infinite programmers in the world are going to sit in the room and code up all of these." So he needed to invent a new conceptual framework within Microsoft – as he saw it, "to create this language where it's not about probabilities of what you know, but what you *don't* know".

* * *

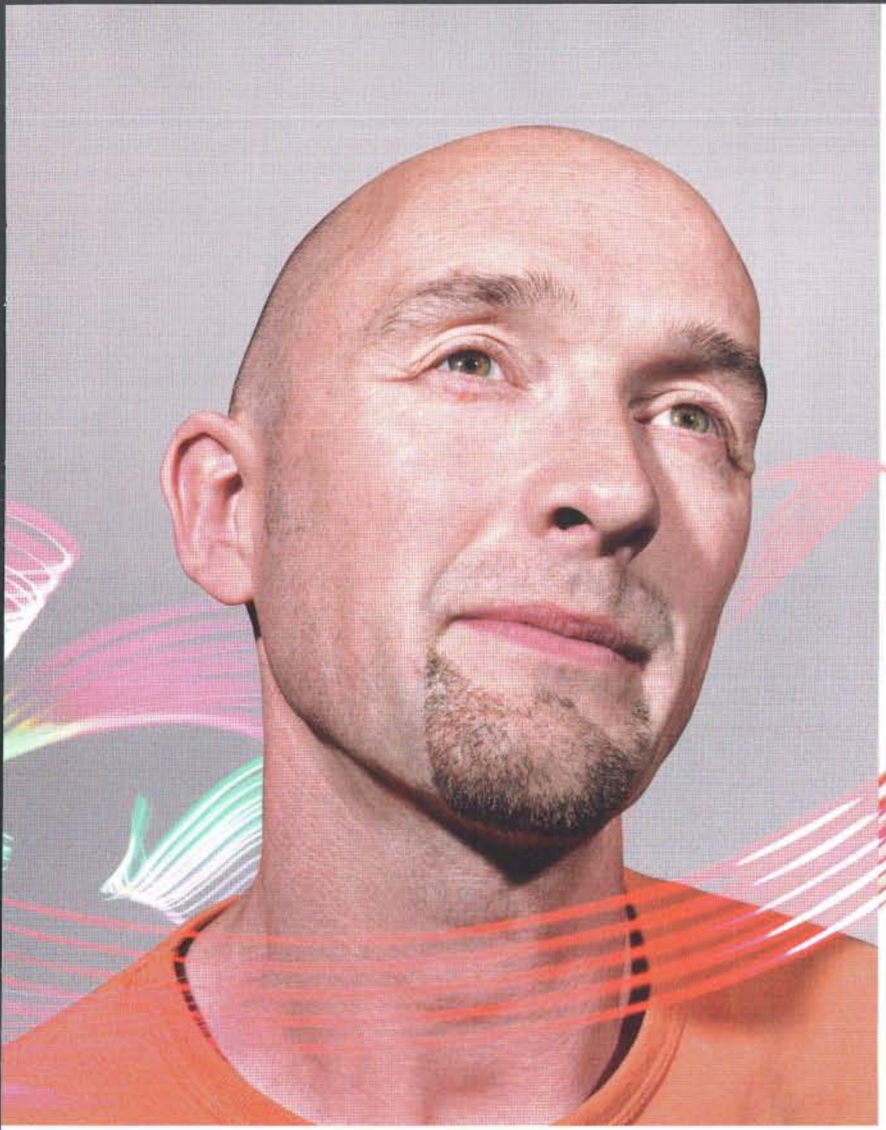
Tamir Berliner met three of the four other PrimeSense founders in the same unit of the Israel Defence Forces. "The advantage of being in the Israeli army is you're trained at a very young age and they give you tasks that often seem unsolvable," Berliner, 29, explains. "You have to think creatively. So the fact that we faced 'unsolvable' problems at PrimeSense never scared us."

Launched in May 2005, the Tel Aviv-based startup employs 130 staff and has recently opened a further five offices in Asia. The problem it set out to solve was how to use a depth sensor to map a moving person. "Our starting point, as gamers, was that computer games were getting boring," Berliner says. "We wanted more immersion – so you could actually throw a fireball in the game. We wanted to take it to full-body games."



Right: Alex Kipman, Microsoft's Xbox 360 incubation director. *Opposite:* Nick Burton, Rare's development director for Kinect

PHOTOGRAPHY: JOHN KEATLEY



Beside his desk sits the first iteration of the resulting product: a white plastic box, around 30cm long and 10cm wide, containing an RGB camera, an infrared sensor and a light source. That was first demonstrated in March 2006; two months later, PrimeSense took an upgraded version to E3 in Los Angeles. When Kipman first saw the tech, his heart raced. "He totally got it and understood what could be done with the technology," says Berliner, responsible for "software and vision". "He's a visionary."

The Xbox team contracted PrimeSense, amid secrecy, to provide Kinect's depth-sensor chip and reference design. (Microsoft acquired another Israeli startup, 3DV Systems, which made 3D digital cameras.) Now all that was needed was to shrink the camera sensor and slash the price. "The hardware has to disappear in a way that makes it almost invisible to the user," explains Raghu Murthi, who runs the natural user interface (NUI) hardware group for Xbox 360, "so that the consumer is always interacting with the system, but not really aware of how."

> **'THE HARDWARE HAD TO DISAPPEAR IN A WAY THAT MADE IT ALMOST INVISIBLE TO THE USER'**
>
> RAGHU MURTHI

At the start of 2008, Kudo Tsunoda joined Microsoft Game Studios from Electronic Arts to run *Gears of War 2*. Early one afternoon, during induction meetings with Tsunoda's new Redmond colleagues, Alex Kipman came for a scheduled appointment carrying hardware based on the PrimeSense camera sensor.

Tsunoda had never been one for conventional offices: instead, he had hung a curtain to demarcate himself a makeshift corridor space by the lifts. The tech that Kipman demonstrated behind that curtain was basic – it showed a raw 3D view of the space, with no sound, nor RGB images – but Tsunoda was transfixed. "There was such a burst, of, 'Wow, here's 100 things we can do with this,'" he recalls. "Creatively, it was very exciting." The two hit it off so well, their meeting overran by four hours.

Tsunoda was especially taken by the lack of controller. "Growing up seeing the *Star Trek* holodeck scenario, where technology enables you to have a fully immersive experience – we talked about this as the first step towards that. Going into a room and, wow, suddenly being in a totally different environment."

Yet his excitement was tempered by a quick reality check. "You leave the meeting and think, 'Yeah, we're not going to be able to do that,'" he recalls. "You could stand there, maybe move your arms and legs and see those types of movements on screen, but it wasn't able to track you with any velocity or variety of motion." The pair knew they would need to incorporate microphones for voice interaction, and an RGB camera so that players could see themselves clearly on screen.

But bigger challenges remained.

* * *

Like Kipman, Tsunoda had a small incubation team who quickly prototyped around 70 game experiences. Soon some "awesome cool stuff" emerged. When Kipman's team prototyped a wireframe skeleton that moved with a player's body, his and Tsunoda's teams were transfixed. "You'd have people sitting for 40 minutes playing with this super-engaging skeleton", Tsunoda says.

Human recognition, however, was a huge hurdle. "People change – I used to have a giant beard; body weight changes. There was no system set up for that," says Tsunoda. And voice recognition proved a problem amid ambient noise.

But if these challenges could be cracked, he saw huge social benefits. "Most technology divides human beings," he says. "At a dinner party, ten people are interacting with their phones. I'm very focused, creatively, on using technology to bring people together – to have more meaningful human interactions without that technology layer."

Growing up outside New York City, Tsunoda, now 36, recalls enjoying freeform play experiences that he says have largely disappeared. "I remember just going down to the park, making up in your head the games you'll play based on what's around you in a very unstructured way – sports games, strategy games in the woods. It's the stuff that's best trained me for today."

So what can we expect from Kinect in the future? "One of the super-interesting parts is being able to interact with a computer character in an interesting way. The human-recognition technology gives us that – with *Kinectimals*, it's super-cool how that animal reacts to me differently from anyone else. Then there's voice. We have a good understanding of voice recognition, but a lot of communication has to do with intonation and body language. That's the stuff we're working on to make for better interaction with computer-generated characters."

More immediately, he is excited by a prototype that will let users "take a really complex physical object, hold it up to the sensor, and allow [them] to play with that object in a digital format. Which is super-cool. This is just wave one.

"And the full holodeck. Did we announce that yet? I think it's coming in 2012..."

Kipman, Tsunoda and their teams worked towards a deadline: a meeting of Microsoft executives on August 18 2008 when the project would be canned or green-lit for further development.

"We brought into that meeting a set of sensors Scotch-taped together," Kipman recalls. "We didn't tell the execs anything about the technology. We didn't say anything about what had been done behind it. We just said, 'All you need is life experience. We're not going to tell you how this stuff works. Get in front of it and play it. It's a car. Drive!'"

Marc Whitten saw the meeting light up when the technology was demonstrated. "Everybody just smiled. The visceral reaction was incredibly powerful."

Kipman had bought time, but big questions remained. Straight away, Whitten recognised two things: "First, this was going to be really hard. We've talked about the nine miracles needed to make this happen." (He will not specify what they were.) "It was, 'Yay, we're down to eight.' And the second thing I thought was that this wasn't a game controller. It was much, much broader than that."

* * *

Thirty-two black pyramid cubes sit piled neatly on the window-ledge of Andrew Blake's office deep within Microsoft Research's Cambridge campus. The cubes – awards for Microsoft patents, from "Gaze Manipulation" to "Patch-based Video Super-resolution" – reflect the vast academic challenges overcome by Professor Blake, 54, since arriving here in 1999.

Blake, now deputy MD, is one of the world's foremost experts on computer vision, his research used in fields from heartbeat-tracking medical imaging to a "smart erase" background-removal tool for editing photos in Office 2010. Many of his breakthroughs use mathematical physics to map the probability that a particular pixel belongs to a heart as opposed to a kidney, or to a smudge that you want erased from a holiday photo. But training a computer to track a moving human body? That had proved a more insuperable problem.

In three decades Blake had helped design laser-rangefinders that could track military helicopters by watching the ground, and had helped an agricultural institute map cabbages on farmland for more accurate crop-spraying. But that was at a time when it could take an entire day for a computer to process a single image frame. Representing a person's movements in real-time on a screen was a far-off dream. But in 2001, Blake published an academic paper with a fellow Microsoft researcher, Kentaro Toyama, that raised an intriguing new approach to following moving objects.

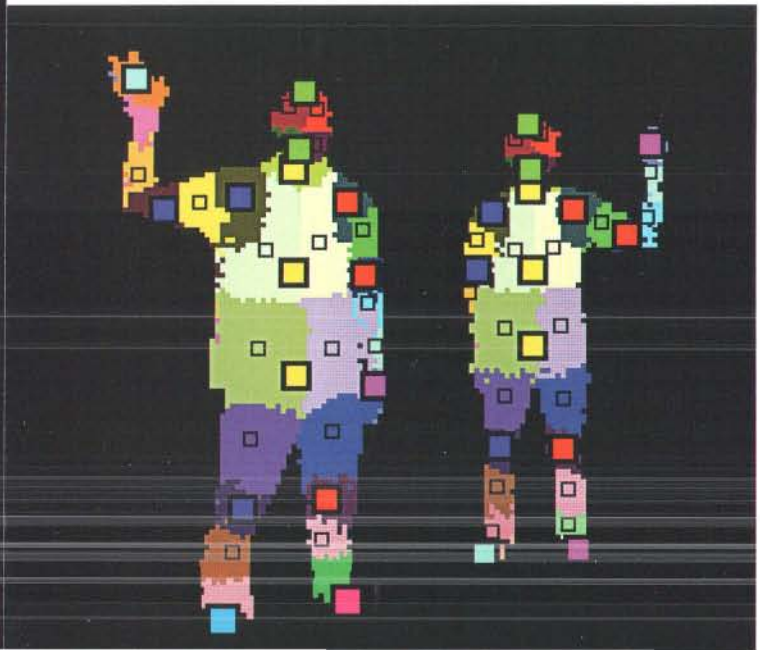
The paper, *Probabilistic Tracking In A Metric Space*, suggested that a ballet dancer's movements could be tracked by assigning a probabilistic likelihood that each frame would lead on to any other frame. By feeding a computer raw data of a ballerina's typical movements, each snapshot – Blake called them "exemplars" – could be automatically assigned its most likely next frame.

The approach – "like having a flipbook of cartoons with prototypical poses", as Blake explains it – sent a wave of excitement through the world of machine learning, and the paper won the prestigious Marr Prize. It also influenced a former post-doc at Oxford, Andrew Fitzgibbon, who specialised in computer vision. Fitzgibbon's work on automatic camera tracking had spun out into a commercial product, boujou, which helps 3D animators to impose special effects on a live-action background and has been used in *Lord of The Rings* and the *Harry Potter* films.

In 2007, Fitzgibbon, now 42, co-authored a paper, *The Joint Manifold Model for Semi-supervised Multi-valued Regression*, which again examined how probability could be used to infer a human body's motion. Fitzgibbon, now based at Microsoft Research down the corridor from Blake, recalls feeling "pretty chuffed" with the results. But the approach had one huge limitation: it could work only on a narrow range of about 50 body movements. And image processing was extremely slow: it took

SOME LAUNCH KINECT GAMES

- *Joy Ride* (BigPark)
- *Kinect Sports* (Rare)
- *Dance Central* (Harmonix)
- *Kinectimals* (Frontier Developments)
- Not scheduled for release: Lionhead Studios' *Milo & Kate*, as demoed at E3 in June 2009 and again at TEDGlobal this July



THE HARLEQUIN MOVE-TRACKER

Left: a still from Microsoft Research Cambridge's "Harlequin" body-tracking demo. It gave each body part a different colour, allowing researchers to train a computer to track movement in real time – and predict the next moves. "This was the missing piece," says Andrew Blake. "Seeing the figure moving, with the harlequin pattern sticking to the body, solved the problems."

around a minute to generate each video frame of movement.

At this point, Kipman's team found a paper from Toshiba, whose researchers were also trying to solve the problem of real-time motion capture – not with a 3D sensor, but with a regular camera.

"They'd taken the work that Toyama and I did and scaled it up," says Blake. "So my flipbook, of around 100 pages, was now much bigger and more comprehensive: their paper reported a flipbook of around 50,000 pages, looking for all the [movement] combinations of the human body."

> **'IT'S AS RADICAL AS THE MOUSE OR THE MULTITOUCH SCREEN. THIS IS NO-TOUCH'**
>
> ANDREW BLAKE

Yet the Toshiba approach could never be comprehensive: as Blake recognised, the permutations of a body's movements were just too great to use probability mapping effectively. "If each body point was segmented into ten angles, there could be 10^{30} possibilities of the next movement. That just wouldn't work."

The answer, by sheer chance, came from the PhD research of Jamie Shotton, a computer-vision researcher in Blake's department who was fresh out of grad school. Shotton had shown how to train a computer to differentiate cows, grass or an aircraft in a countryside photograph by studying it pixel by pixel. He had taught the system to recognise 21 categories of object.

By chance, Kipman had come across one of Shotton's earlier papers about tracking hands. "It was really well written, and the tone was optimistic," Kipman recalls. "I'm, like, 'We've got to go talk to this guy!' Not long after we found out he worked for Microsoft." The call from Redmond came on August 18 2008. Could Shotton help in tracking a body in real time? He discussed the challenge with Fitzgibbon. "My immediate reaction," Fitzgibbon says, "was, 'No you can't.'"

Kipman's team put their Scotch-taped hardware into a bag, packed a couple of changes of clothes, and flew to Cambridge. They had hacked together a video that took advantage of the camera sensor's 3D capabilities. The video showed a man's skeleton being tracked in the foreground; in the background, it showed what the depth camera was seeing. Once the system had recognised the man's body shape, it snapped on to his skeleton; on screen you could see an outline of his movements as he danced. They called this demonstration the "Bones" video.

"This was better than anything out there, but 'Bones' has three main failings," Shotton says. "You have to start in a particular position for it to lock on to you. If it stops working, you have to go back into that position. And it only really works for one body size. All assumptions about size and body shape are hard-coded into the algorithm."

The problem with the "Bones" body-tracking approach was that bodies do not always move predictably, and are not all alike. So the system made frequent errors in estimating where a limb or a head was moving next. But what if Shotton and Fitzgibbon went back to Andrew Blake's "exemplars" work on ballerinas, whereby the system made frame-by-frame calculations of each body part's probable next move? If each frame was treated in isolation, the computer could be trained to predict the next frame.

But the data needed to train it would be vast. "We thought we could get away with 10^{13} examples – but that wouldn't fit in the Xbox's memory," says Fitzgibbon. "Let's say your left hand has 1,000 possible combinations of its next move. For both arms simultaneously would be a million combinations! It was an exponential complexity."

They brainstormed further about how to divide up the body. Eventually Shotton suggested revisiting his PhD research – involving cows, grass and aircraft – and adapting the same pixel-by-pixel classification to the human body. This was the breakthrough moment: if the machine-learning system could be trained to recognise individual body parts – and the depth sensor could help – then the "Bones" system would initialise regardless of your pose.

Fitzgibbon plays a demonstration video in which each body part – from the upper-left arm to the right foot – has been colour-coded, and the colours follow the body as it moves. They call this the "Harlequin" video: the human figure resembles a clown wearing a harlequin suit, with a different colour for each of 31 body parts plus one for the background. "The machine-learning algorithm has been told this pixel here is a shoulder pixel, while this pixel in another image is also a shoulder pixel despite looking quite different," Shotton says. "If you can get enough variation in the millions of poses it's been trained with, you can effectively teach the algorithm to ignore the fact that you've changed pose, or got a bit fatter, and keep the important information that this is a shoulder pixel." (Finger movements, for now, can't be resolved because of current limits of camera resolution.)

"This was the missing piece," says Blake. "Seeing the harlequin figure moving on the screen, with the harlequin pattern sticking to the body, solved the two problems – what happens when you come into the room, plus rapid movement."

They named this the "Exemplar" system, and began to train the algorithm with 100 computer-generated images of people. By June 2009, it was ready for its first public demonstration at E3 in Los Angeles. "Up to that point, I hadn't told my family what we were working on," Blake recalls. "Not even my wife knew." The team's final handover to Redmond came six months later.

Shotton did not get to play any of the launch games until August 2010. "I was amazed at what they'd done with this," he says. So what does he see as potential future applications? "Anything where motion is important, such as physiotherapy, or bowling practice," he says. "And in massively multiplayer online games – you can imagine your full body mapped out and interacting intuitively in the game."

"Or imagine a surgeon with hands-free control of devices in an operating theatre," says Fitzgibbon. "Or clothing – in a movie, [actors] will wear £50 Savile Row suits, as a 3D camera gives you a perfect fit."

For Blake, the bigger excitement lies in what this project means about the future of man-machine interaction. "It's as radical as the mouse or the multitouch screen," he says. "This is the no-touch screen."

Cambridge had given Kipman his new "language". The project sped ahead, moving from incubation to the software-platform group under Ben Kilgore. "We broke everything down into three or four core problems to solve," Kilgore says. "Within each were 20 subproblems. We had this mantra of, 'We must fail fast.'"

For voice recognition alone, the tasks were vast. "We built an acoustic model for each country with speech support," Kilgore says. "You have to build a statistical sample of people from different regions and dialects. We went to the deep south, and we'd have people with accents run through manuscripts. Then we'd go to New England, Boston, Minnesota."

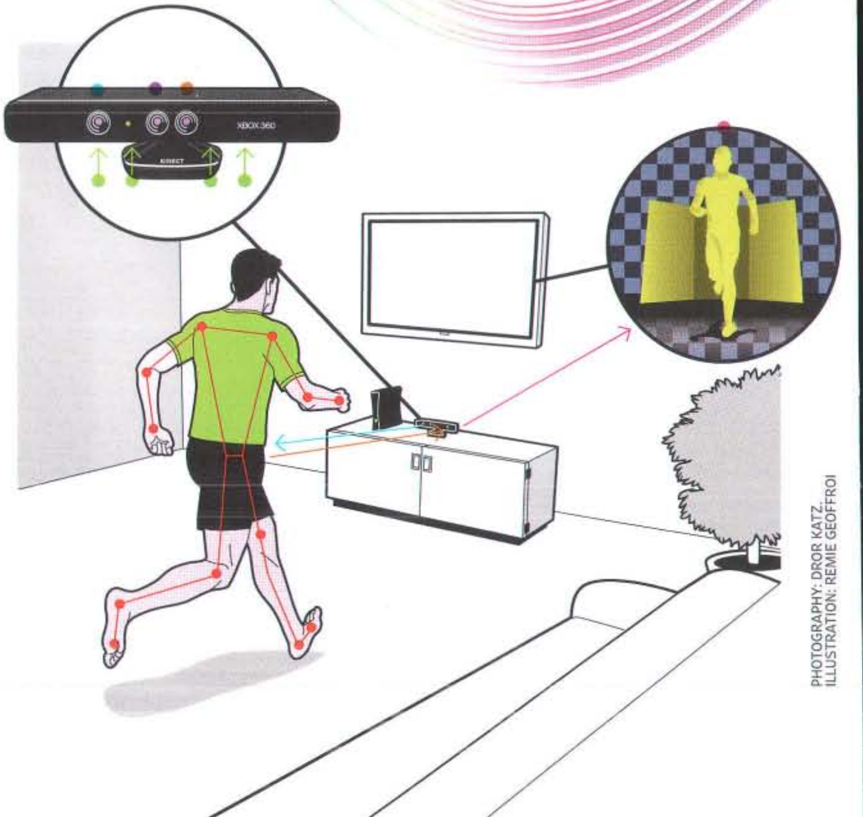
Rigorous testing was vital – of hardware, software and the games that were starting to emerge. Hardware testing involved gamers playing in a variety of temperatures, humidities and light conditions. "We have huge ovens where we keep the product at high and low temperatures to simulate different user conditions," Raghu Murthi says. "We have anechoic chambers, where there is no external noise coming in, and we test microphone arrays and audio systems."

In June 2009, when Project Natal was revealed at E3 in Los Angeles, Peter Molyneux of Lionhead Games showed a video of an in-screen character called Milo talking back intelligently to Kate, the real-life woman chatting to him through

The first version of PrimeSense's depth sensor, from 2006, which impressed the Xbox team

KINECT: HOW IT WORKS

- ● An infrared projector bounces a beam out across the room.
- ● A standard active-pixel CMOS image sensor (used in mobile-phone cameras) captures the reflected beam.
- ● A PrimeSense chip in the CMOS sensor maps the signal from the camera, creating a topographic view of the playing field. This assigns a distance value to every pixel in the frame. (The yellow image is a representation of the data – but the computer just sees numbers.) The Kinect depth sensor's range is from 1.2m to 3.5m.
- ● Software filters this image, separating chair legs from humans', and identifying body parts such as your left elbow.
- ● Kinect converts this data into a skeleton with moving joints – the basis of your on-screen avatar.
- ● Four downward-facing microphones pick up voices from up to three metres away. "Beam-forming" software works with the depth sensors to create an envelope of sound around you.
- ● An RGB camera, synchronised with the depth sensors, is used for videochat or background-removal.
- ● A motor subsystem tilts the sensor up and down to capture the best field of view for the particular playing area.
- ● The whole process refreshes at 30 frames per second. **TC**



PHOTOGRAPHY: DROR KATZ.
ILLUSTRATION: REMIE GEOFFROI

the sensor unit; Milo even reads her facial expressions to detect her mood, although the demo prompted some online scepticism about the veracity of its real-time action. This July, Molyneux again presented Milo to the audience at TEDGlobal in Oxford as “a revolution in storytelling”. “Entertainment, film, TV, even the hallowed book, are just rubbish,” he declared. “Why? Because they don’t involve me, the audience. I hate that. I love the future that Milo brings.” No Milo game has yet been scheduled for release.

* * *

Deep within a landscaped campus set amid 36 hectares of Warwickshire parkland, past an unmarked security entrance off an unnoticed country lane, Kinect is being tested to its limits. It’s the last days of bug-fixing for Rare’s *Kinect Sports*, and in a series of custom-built development barns set around central offices, dozens of the company’s 200 staff and contractors are sweating, quite literally, to ensure the ten featured sports, from bowling to boxing, are ready for showtime on November 4 in the US and six days later in Europe.

In a downstairs test room, two women in full gym kit are playing table tennis by frantically waving their hands as another woman boxes energetically into the air. Upstairs, where developers sit with artists, coders and programme managers, the view down the corridor is surreal: as one man runs on the spot outside his office door, another shouts “Goal kick!” and a third is visible initially only as a protruding posterior until it becomes apparent that he has been throwing an imaginary javelin. “Here’s where I suffered my first Kinect injury,” says Nick Burton, Rare’s development director for Kinect, as he points to a low beam over a doorway. His colleague George Andreas, Rare’s creative director, explains that these barns contain the highest concentration of Kinect cameras in Britain.

Nearby, games are being tested on vinyl flooring, wood strips and carpet tiles (to emulate the varying reflectiveness of users’ homes) and also, loudly, in Spanish. The office decorations serve as a reminder that Rare, bought by Microsoft Game Studios in 2002, has long been a giant of gaming: wall posters for *Banjo-Kazooie* and *Conker*, display cases of original *Donkey Kong* games for the Super NES and N64, large promotional statues for *Star Fox Adventures*.

Tsunoda approached Andreas in August 2008. “We’d heard on the corporate grapevine of a new motion-capture system that didn’t require you to wear a suit with ping-pong balls, which would work in your living-room,” says Burton. “I thought, ‘Yeah, right.’” Sceptical, they delayed a visit to Redmond until October. Even on the plane over, Andreas dismissed the idea as “pie in the sky”.

The four Rare executives on the initial trip met Kipman, Tsunoda and their teams. “Alex’s office was a den of wires and boards, like a mad professor’s lab, with one of the old PrimeSense units gaffer-taped to the TV,” says Burton, 39. Then he saw a demonstration of the “Bones” skeleton on screen mimicking his movements, and he was awestruck. “That was my Natal moment. At the time the skeleton didn’t automatically lock on to you – you had to walk into it. But I was amazed. I sat in Kudo’s office and refused to leave until he gave us some developers’ kits.”

They returned and began prototyping possible games. “Some of the concepts were really off the wall,” says Andreas, 39, at Rare for 15 years. “[Such as,] ‘Wouldn’t it be great if the rug in your living-room suddenly sprang to life where you’re riding a raft with sharks swimming around?’” Burton continues: “There was the mad dancing *Saturday Night Fever* idea, where different moves would pop a huge glitter ball out of your ceiling.”

But with Andreas having once played semi-professionally for Crystal Palace, a football game was inevitable. “We knew we could kick a football in 3D,” he says. “But one of the hardest things in real football is juggling a ball. I thought that would prove the technology. So we started working on a simple prototype – and it worked.”

Over Christmas 2008, they narrowed their focus on three ideas, sport being one. “We wanted to compete head-on with *Wii Sports*,” Andreas admits. “We knew we could do so much more with Kinect than you could with Wii.”

* * *

Because the launch titles were aimed at the family market, Rare chose the more popular sports. “We put a bowling prototype together in three days: can we significantly improve on *Wii Sports*’ bowling? Could we allow people to run at the screen with the ball? We realised we *could* improve on it.”

The team prototyped almost 20 sports, from horseracing to cycling, whittling these down to six (with five events within track and field). Football went through the most iterations: “I probably inhibited the creative process,” Andreas admits. “We created real football, but, boy, was it hard to play. My mantra was that it had to be football for the masses.”

Software drops were arriving daily from Redmond. There were glitches as the team moved from working on PCs to Xbox – with football, leg tracking proved unreliable and latency increased. That, Andreas says, was the low point. These issues took three months to resolve. “It’s amazing,” he reflects. “It’s not even [been] two years, yet we’ve got new technology, new software, new hardware, new ways of talking about games.”

What’s next, then? “The initial wave of experiences are those people can relate to,” Andreas says. “After that, that’s when we can really go to town. You can create any experience on Kinect – shooting games, fighting games, adventure games; it’s how you tackle that subject. A lot more can be done with face recognition, with voice recognition.”

> **‘ENTERTAINMENT, TV, FILM ARE JUST RUBBISH. WHY? BECAUSE THEY DON’T INVOLVE ME’**
>
> PETER MOLYNEUX

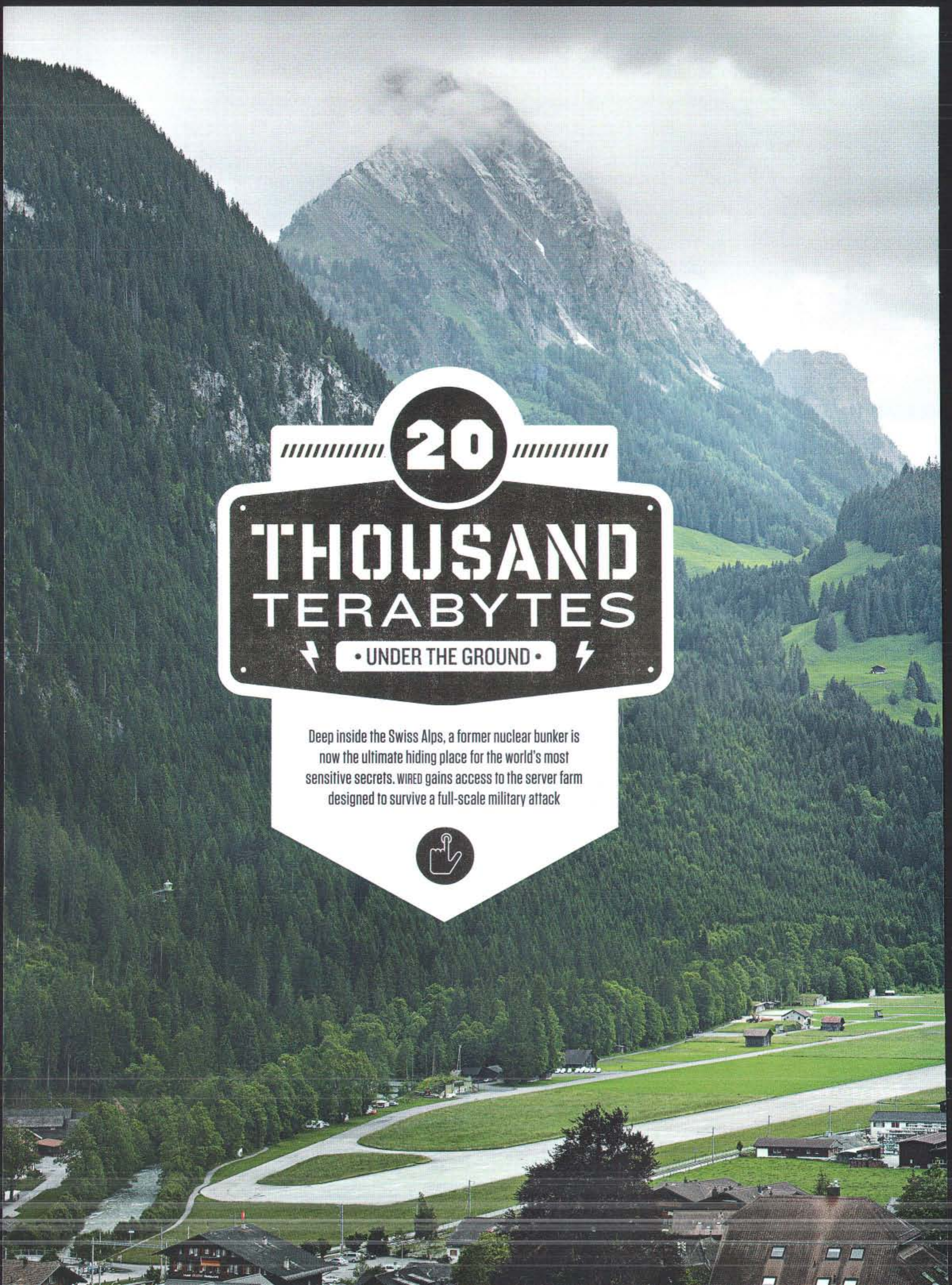
“The clever thing about Kinect is they’re all married together,” Burton says. “From an input point of view, it becomes more than the sum of its parts. If we wanted speech recognition to know it was me speaking – that’s hard. But if Kinect is tracking me, looking at the skeleton, it can see if that movement is where the sound is coming from. It can then look at the RGB feed to see if the RGB is moving around that person’s mouth.”

“It knows Nick is speaking with just five lines of code,” Andreas says.

What of the expectation, raised in the Milo demos, that players might have full conversations with on-screen characters? “Realistically, if you want a one-to-one conversation with an AI-driven character, that’s at least five years away,” Andreas says. “But thinking about where that tech is going,” Burton adds, “if it’s cloud-based, passing the Turing test becomes much easier. You just need a huge internet-like database, then work out how to datamine that.

“On November 4, that’s not where it stops. That’s just the beginning.”

David Rowan is the editor of WIRED. *He wrote about the app explosion in 02.10. Kinect launches on November 10 in Europe*



20 THOUSAND TERABYTES

• UNDER THE GROUND •

Deep inside the Swiss Alps, a former nuclear bunker is now the ultimate hiding place for the world's most sensitive secrets. WIRED gains access to the server farm designed to survive a full-scale military attack

PHOTOGRAPHY BY TODD ANTONY

BY IAN DALY

ILLUSTRATION BY MIKEY BURTON

The cockpit of Christoph Oschwald's silver Audi A8 is preternaturally quiet as he steers through the Swiss countryside towards our destination. WIRED has been instructed not to disclose its exact whereabouts. It's late June, "the longest day of the year", Oschwald notes. It should be 25°C outside. Instead, it's an unseasonably chilly 12°C, and the tiny village of Saanen, in the canton of Bern, sits beneath a steel-grey sky that lends an ominous air to what might otherwise resemble an Alpenland panorama on a souvenir chocolate bar.

The green valley that cradles Saanen and the nearby town of Gstaad in the Bernese highlands plays host, according to local newspaper *Der Bund*, to the highest concentration of billionaires in the world, their chalets creeping up the piney slopes. But it's also home to something else – a place that you won't find on any of the tourist maps. For the past 18 years, Oschwald, 53, a retired Swiss paratrooper turned contractor, and his business partner, an engineer named Hanspeter Baumann, 55, have committed thousands of hours and millions of francs to realising their vision – the place we're headed to today.

We pass a Tissot boutique abutting a tractor dealership before the road dives into dense forest and follows a stream. Finally we arrive at our destination. At first, it appears to be nothing more than a timber operation, with lorries moving wooden payloads around a gravelly clearing. But then we see them: three guards clad in black uniforms, berets askew, pacing at the base of an enormous mountain. The Alpine foliage above the sentry ends abruptly at a bare rock face painted in fading camo. And carved into the side of the mountain is our destination: a small, weather-beaten metal door. Once the entrance to a vast nuclear bunker built by the Swiss military at the height of the Cold War in the mid-60s, it is now a portal into what its creators claim to be the most secure and secretive storehouse for digital information in the world: the place Oschwald has christened Swiss Fort Knox.

"Sixteen years ago, nobody took us seriously," Oschwald says. "They said to us, 'Storing data under a mountain? Why?'" In the cheerier geopolitical climate of the 90s, it was decidedly easier to scoff at the eccentric Swiss entrepreneur, with his slicked-back hair and blinding white smile, as he extolled the data-security benefits of his decommissioned bunker. But today – with terrorism, environmental disasters and financial meltdown on the global agenda – some of the biggest players in technology and finance are buying into the facility's promise. Oschwald can tick off blue-chip companies such as Cisco Systems, Novartis, UBS and Deutsche Bank among his clients.

The guards stroll over to greet their boss, who is 6′ 2″ and wears a black raincoat and a dark-blue Italian suit. As he prepares to escort

WIRED inside, he explains how nearly two decades of work and an investment of more than 40 million Swiss francs (£25 million) transformed a decaying bunker into a fortified data repository. Swiss Fort Knox has a laundry list of features straight out of a film script. There are five security zones, a dedicated power supply, a cooling system that pumps glacier water from an underground lake, military-grade air filters that siphon atomic, biological and chemical impurities from the air, an emergency hotel, several months' food, a conference room, and security, including face-recognition surveillance software, bulletproof plastics and vault doors

FIVE MILLENNIA OF DATA STORAGE (OBSOLETE FORMATS IN GREY)

3000BC

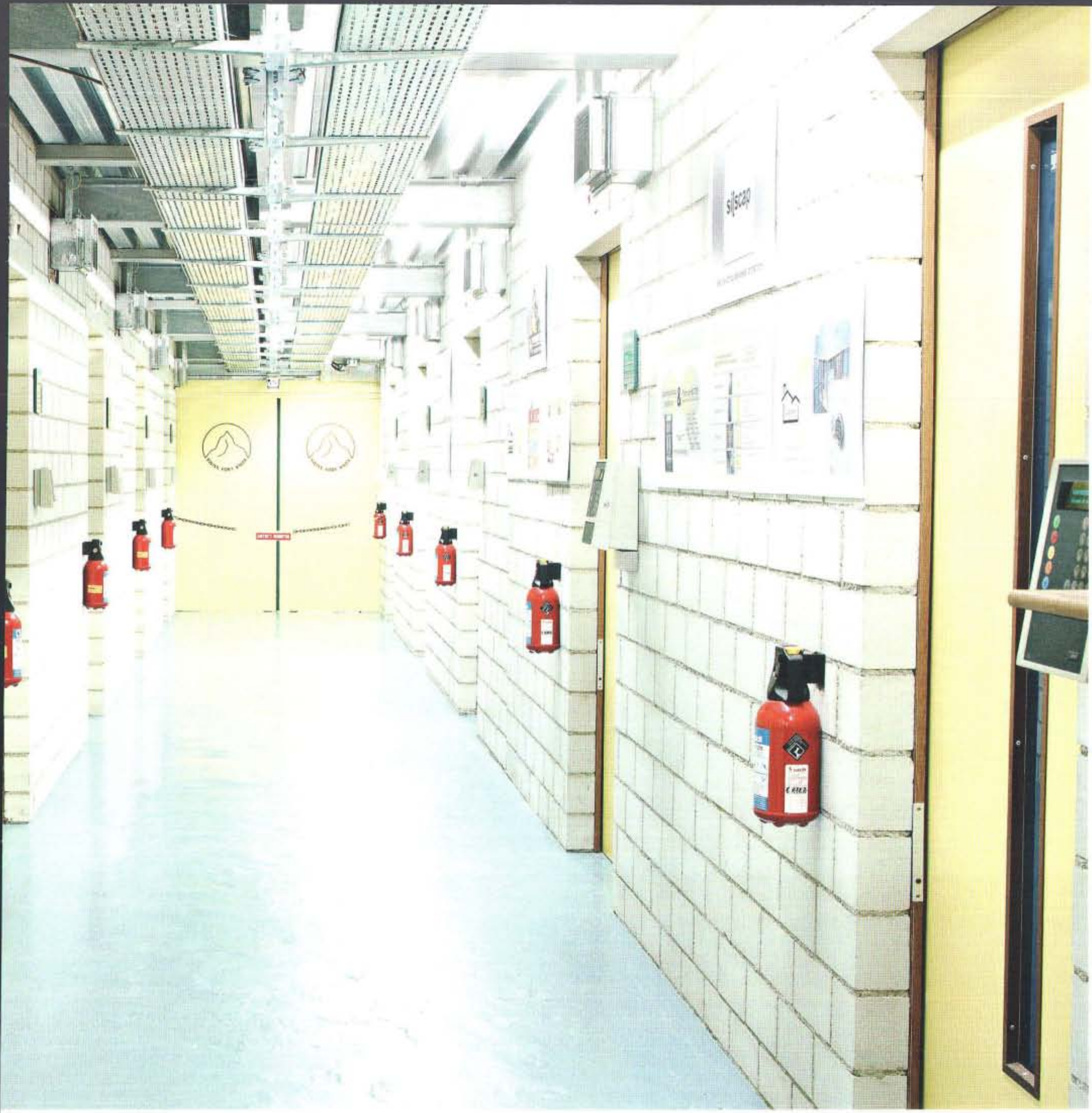
PAPYRUS
Papyrus was hoarded by the library at Alexandria, which forced the rest of the West to look for a replacement, ushering in parchment and paper.

500BC

PARCHMENT
Developed in Europe 2,500 years ago, parchment is a thin material made from calfskin, sheepskin or goatskin.

105AD

PAPER
The paper we now know was made from plant-fibre pulp and invented and popularised by the Chinese Han dynasty.



courtesy of the Swiss banking industry. It is also, thanks to its original use, designed to be impervious to nuclear attack.

"We had a four-star US general who was partly responsible for the atomic-weapons programme come here," Oschwald says as the guards look on, "and he said, 'In America, we have a lot of space and a lot of soldiers. But I have visited a lot of sites and this is something... very special.'" As Oschwald speaks, a Subaru pulls up and a stocky man in sunglasses exits the car carrying a light-blue lockbox. He says a few words to one of the guards, hands over the goods and speeds away. Oschwald seems unfazed by the spectacle. He's accustomed to nervy clients who still prefer physical data transfer to the virtual.

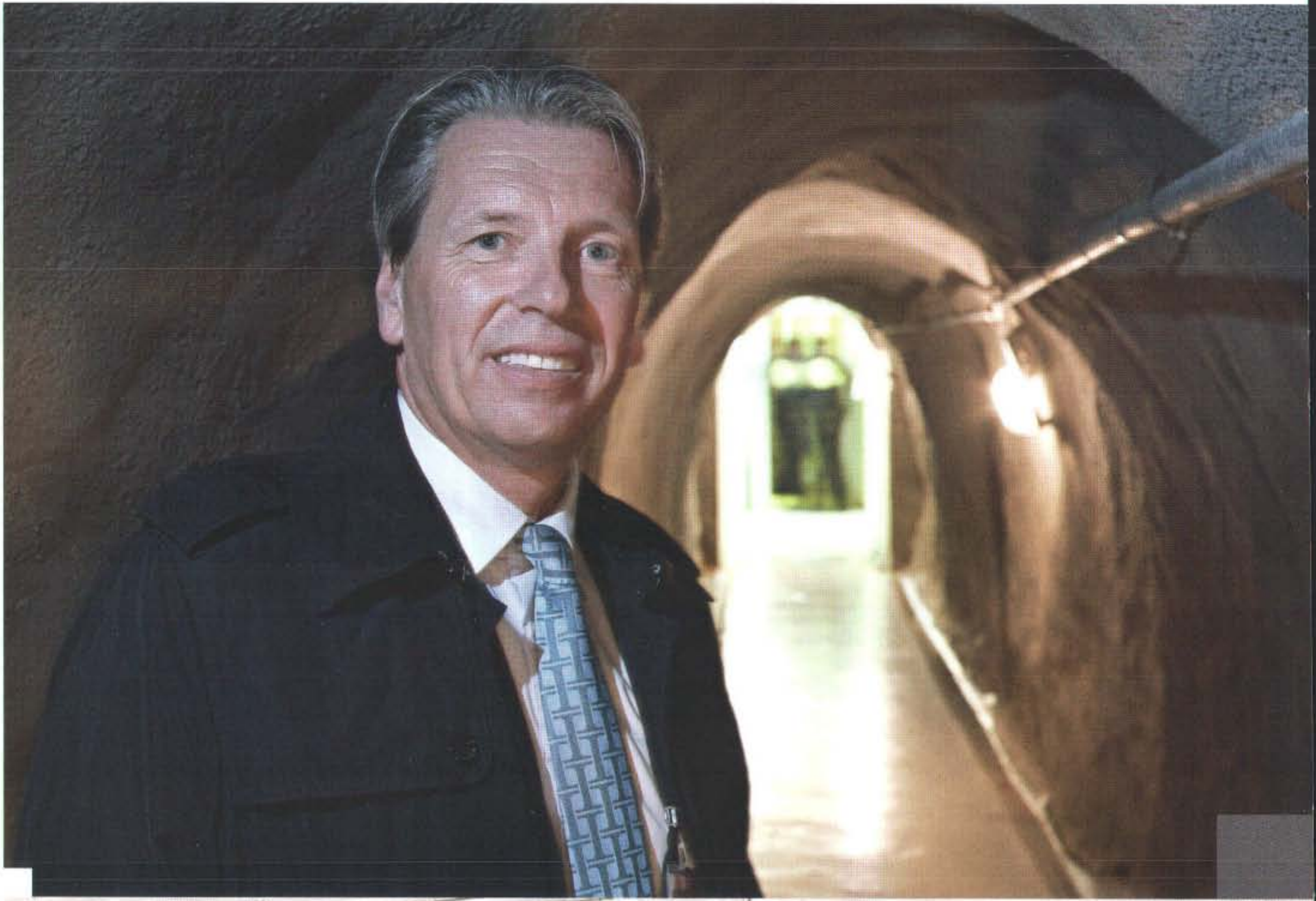
(*Above*) Area 4, the most restricted sector of Swiss Fort Knox, accessible only by clients; (*below*) the mountain entrance

1725

PUNCH CARDS
Originally pattern "programs" for fabric looms, they were used in the 20th century as input mechanisms and data storage for computers.

1928

MAGNETIC TAPE
Invented for audio, tape is also used for video- and computer-data storage. It's often more viable – and cheaper – than a hard drive.



"Normally we have courier services bringing those boxes once a day," Oschwald says. But this delivery was special. "The point is, data is more valuable than money – because money is replaceable, data is not. What we need is a bank for data, and this is where the Swiss tradition is. The material value of that blue box is maybe a thousand bucks. But the value of the information? This could be billions."

Last year, Oschwald received a phone call from a software professor at the University of Vienna named Andreas Rauber. He wanted to know if Oschwald would store a sealed metal container within which were the tools to decipher every major file format then in existence – a kind of Rosetta Stone for the digital age.

The honour, Oschwald responded, would be his. And so it was that last May, an impenetrable subterranean fortress carved into the side of a Swiss mountain became the home of the world's first digital genome.

Bits rot. It's a difficult thing to accept about the seemingly intransigent, but those ones and zeros still rely on physical objects – CDs, DVDs, microchips, hard drives, memory cards – to hold them steady. And this is the realm of chaos. Over time, electrons rearrange themselves, polarities reverse, heat jostles, UV rays fry. In 2001, a geologist from the Museum of Natural History in Madrid discovered a new form of fungus that eats compact discs, rendering them unplayable. Far-fetched as it may sound, forces of nature ravage our digital information, the way a jungle reclaims ancient cities. What's worse, files don't decay the way written documents and photographs do. One misplaced bit in a .jpg file and the whole image could fall apart. Assume, for a moment, that you desperately needed to access a file you created 15 years ago. Where will you insert that floppy? Where will you find a copy of WordPerfect 6.1? And what are you going to save it on to this time?

(*Upper left*) Christoph Oschwald; (*lower left*) a data-storage room, kept at 18°C; (*right*) the Mount10 backup servers

Scale this hopeless scenario up to several decades' worth of digital information, and you'll have some sense of why a consortium of 16 technology companies, national archives, and research universities across Europe – IBM Netherlands, the University of Cologne and the Swiss Federal Archives among them – have dedicated four years and more than €15 million to an initiative known as the Planets (Preservation and Long-term Access through Networked Services) project. Planets is co-ordinated by the British Library's head of digital library technology, Adam Farquhar, and its mission statement is "to enable long-term preservation of digital content, increasing Europe's ability to ensure access in perpetuity to its digital information." It's a mission it takes very seriously.

On a bright June afternoon at the British Library's sprawling Boston Spa campus in rural Yorkshire, the hillsides are exploding with yellow rapeseed blossoms. Farquhar, 49, bespectacled with a big black beard and an indomitable demeanour, meets WIRED in his sunlit office to talk about the birth of the digital genome. Six years ago, he came to the library to put together a preservation team that would look after the digital collection for the foreseeable future. But the challenges of obsolescence and unreadability became immediately apparent – and for that matter had never really been addressed before. "Preserving the data was one thing," says Farquhar, "but how could we preserve it in such a way that it's accessible and meaningful in the future?" So he started a project with the National Archives, research universities and tech giants such as Microsoft and IBM, to brainstorm a solution. The Planets research project was born.

"Andreas Rauber at the University of Vienna had the idea to do this as a time capsule," he recalls. Farquhar loved the idea, and so he and his team embarked on the long journey of configuring its contents. The time capsule, they decided, would consist of five core "source objects": the Planets brochure in PDF, a few lines of Java Code, parts of the Planets homepage in HTML, a JPEG picture of the Planets all-staff meeting, and a short MOV video. It also contains a full menu of storage media old and new: punch cards, microfilm, floppy discs, audio tapes, CDs, DVDs, USB and Blu-ray.

With posterity in mind, Farquhar's team initially approached the Svalbard Global Seed Vault [see page 142] in the remote Arctic archipelago, 1,300km from the North Pole, a worst-case-scenario storehouse for thousands of cultivated botanical strains from around the world.

"We thought that would have been beautiful, very interesting – and it linked in very nicely," Farquhar says. "We were looking for somewhere safe that would last a long time. But they're very careful about any physical object that goes into the vault. That would have been a board decision and they couldn't do it on our timeline."

Rauber had a backup plan – a place just as impervious but closer to home, the Swiss Fort Knox. Rauber and his team, a

1956

HARD DRIVES
Invented by IBM in 1956, hard drives have been the dominant data-storage devices in computers since the 60s.

1969

FLOPPY DISKS
Also invented by IBM, floppies came in three sizes. The most popular, the 3.5" disk, held a mighty 1.44MB of data.

70s

SOLID-STATE DRIVES
SSD technology originated in the 50s, but it was only in the 70s that it was more widely used, in early supercomputers.

1976

CD
A CD stores up to 700MB (80 minutes of audio). Not a permanent storage device, as the plastic degrades with time.

public-relations representative from the university and a graduate student, met Farquhar at the hotel the next morning where they assembled the contents of the time capsule into a metal box, loaded it into a black SUV, and made their way to SFK. "It felt very sensible," he recalls, sitting at the round white table by the desk in his tidy office. "I think it's helping to raise awareness globally about the fragility of our information and the risks to it. We're just on the cusp of having held digital information long enough that we're beginning to feel this."

"Just three rules before we go inside," Oschwald says, holding up a trio of tan fingers. "Photograph anything, but we don't want our staff to be recognised. My face, nobody has a problem if they kill me. But we don't want people to run around with pictures, saying, 'These are the guys, let's take them.' The second thing is that we don't want a manual for how to get inside Swiss Fort Knox. And when visiting an IT area, you will see IP addresses and client names. We don't want you to photograph them."

And there is one more thing. "We don't go into every part of the mountain," Oschwald says, "because otherwise, we would still be there in the nighttime." With that, Oschwald mutters a few things in German to a guard, who takes out a set of keys, unlocks the creaky metal door, and ushers us into the darkness. We shuffle through a curved tunnel of rock lined with incandescent lighting. The acoustics are like a steam room's. Oschwald's baritone voice bellows off the textured walls of the cave as he tells us about the night a couple of years ago when some local kids were foolish enough to graffiti the rock wall in the front. The misdemeanour was recorded in infrared, ultraviolet and visible spectrums. "When they got back to town, the police were already waiting for them," Oschwald says. It was the closest thing to a "threat" SFK has ever had, but there are no plans to downgrade any of the elaborate security measures.

We arrive at an anteroom where two guards armed with pepper spray and truncheons check our bags (guards aren't allowed to carry guns – flying bullets from a gunfight could cause valuable data to become collateral damage). The duo won't leave our sides for the remainder of the visit. A welcome sign is posted in several languages next to a massive yellow door, which Oschwald says is 45cm thick and weighs 3.5 tonnes. The hinges have been coated with Teflon to make them work smoothly – as it swings open, there isn't a squeak to be heard.

"Touch this," Oschwald says, holding his large hand over the place where the enormous door meets the frame. "What do you feel?" There is the faintest of draughts escaping the hairline gap. This, he says, is deliberate, serving a very particular purpose. "The inside is overpressurised. You have always an out-streaming airflow, so nothing can ever come in – no gas, no smoke." The guards assign us ID cards and six-digit codes, which we each punch into a keypad and walk through the enormous vault door – only to be greeted by another checkpoint. Here Oschwald informs me that SFK is divided into five security zones – and we are still in "Area Zero". Area Four, he says, is reserved for about 20 of his most private clients. "*We* don't even go in there."

We've barely moved three metres before we're forced to punch in our codes again and enter, one by one, what looks like a Plexiglas phone box, which Oschwald says is "completely impervious to an M16 rifle". For a moment, both sides slide shut, leaving us trapped in total silence inside a 45cm-wide tube, surrounded by rock on two sides (SFK might appeal to the paranoid, but it is not for the claustrophobic). The door slides open into an even darker corridor. The silence is perforated by the sound of distant dripping water. Oschwald leads us through the hallway to yet another checkpoint. But before we enter, he points out a giant metal door that appears to predate his occupancy. This, he explains, is where Oschwald's territory ends, and the Swiss military's begins. They haven't yet sold off the last portion of their previous domain, and for the past two years he's been trying to cut a deal with them to make his jurisdiction over the compound complete.

"What you have to remember is that some of our clients are coming from countries where governments and militaries are not necessarily their friends," he says, "so they don't want to get in touch with any government or public stuff at all." As we punch our codes at the checkpoint, the yellow door opens into what looks like a city of server towers, their green LEDs flickering as a technician in a white jumpsuit runs diagnostic checks. "In this room we have data for 10,000 clients," Oschwald says.

Physical threats are only one part of the picture, says Steven J Murdoch, a professor and researcher on data security at Cambridge University. "SFK are offering a backup service, which has some desirable protection features, but is by no means a total solution," he says. "For example, the threat of a rogue system administrator deleting all the data because they know they are about to be fired is orders of magnitude more likely than an EMP [electromagnetic pulse] or invasion. The fact that the hosting centre is under a mountain doesn't stop the system administrator corrupting the backup files stored there." Still, a growing number of secure online backup companies such as IDrive, Carbonite, SOS, Mozy and HP Upline are offering similar services, but without the dramatic location enjoyed by Mount10, the

DATA: UNRECOVERABLE

Nasa used to record satellite data on tapes made of whale oil. When whaling was halted, Nasa reused old tapes. Engineers recorded over 200,000 master tapes, including Apollo 11's, leaving only the much lower-resolution copies.

The Ancient Library of Alexandria was the largest in the ancient world. It housed an unknown (but vast) number of papyrus scrolls. The librarians reportedly demanded a copy of every book that passed through the city and its port.

In July 2009, human error wiped the leaderboards of *Halo Wars*, resetting all statistics to launch-day status.

British webhosting company VAServ had 100,000 websites deleted in a malicious hacking attack on its servers in 2009. Only about half of VAServ's clients had chosen to pay extra to have their data backed up.

In August 2010, the UK arm of Zurich Insurance was fined £2.27 million for losing the personal details of over 46,000 of its customers.

1992

MiniDisc

Created by Sony, this tiny disc stored the same amount of data as a CD. They were popular in south-east Asia, but never took off in the West.

1995

DVD

The digital versatile disc can hold up to 17.08GB of data. They are still widely used for media storage.

1999

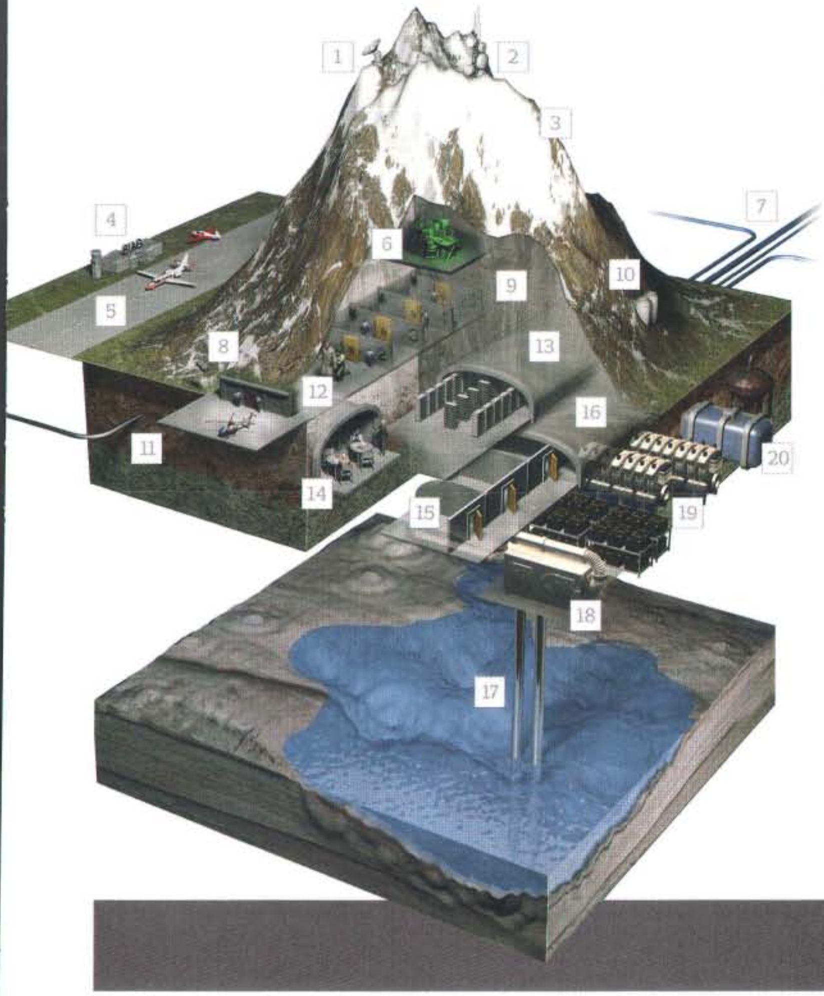
SD card

The Secure Digital card is common in cameras and mobile phones. Some can hold up to 32GB of data.

2000

Blu-ray

Intended to supersede the DVD, Blu-ray successfully saw off Toshiba's rival HD-DVD HD format. Can hold up to 100GB.



FORT KNOX FOR ONES AND ZEROS

1 Satellite connection
2 Radio and optical communications
3 Protection against electromagnetic interference
4 Customs, for fast international access
5 Runway for business jets and helicopters
6 Control centre for maintenance and IT staff
7 Fibre-optic connections to multiple providers
8 Video surveillance
9 Security zones 0-4
10 Air-filtration system
11 All-day supervision by civilian and military staff
12 Security checks
13 Main servers
14 Hotel infrastructure, emergency workspaces, accommodation and catering areas
15 Private data centres
16 Multipurpose rooms
17 Sabotage-proof high-performance cooling system
18 Climate control and "ABC" filters against atomic, biological and chemical impurities
19 Emergency generators and transformers
20 Drinking water

Oschwald company that is responsible for protecting the thousands of terabytes in Swiss Fort Knox.

We are in a dimly lit tunnel next to what looks like a metal oven door carved into the side of the rock. "These are expansion rooms in case you have an atomic explosion outside," Oschwald says. The thinking behind the rooms, he explains, is that if there were a nuclear explosion, the rush of high-pressure air would fill them through vents in the opposite side. Then, the vents would snap shut, trapping the air before it had a chance of damaging the fortress. "There is a lot of protection you can't see," he says. We stroll past an intricate network of insulated pipelines that carry water up from the underground glacial lake to the cooling system.

In another room are two huge drum-like contraptions, which Oschwald explains are military-grade "ABC" filters capable of sapping atomic, biological and chemical impurities from SFK's air supply. Then we enter an area that he refers to as the "emergency hotel". It looks like the crew quarters of a submarine. But at the beginning of the hallway, there is an unexpected sight: a conference room. Its walls are painted in a soothing shade of yellow, and there is a coffee machine in the corner. Oschwald envisioned this as the kind of place his corporate clients could use to hold secret meetings in the event of a crisis, away from the press. But it never caught on. "It was tested, but it was never done in reality."

The four "hotel" rooms, which Oschwald jokingly refers to as "zero- to one-star", consist of two metal-frame bunk beds and a sink. Each room is decorated with a faded picture of an Alpine landscape. Oschwald says that he stayed here for a week while the facility's systems were being set up. "But it's not really what you want. I think if you have a danger and an atomic cloud comes - then you know why you're inside such a facility. But if you have nice sunshine outside, then you definitely don't want to be in here."

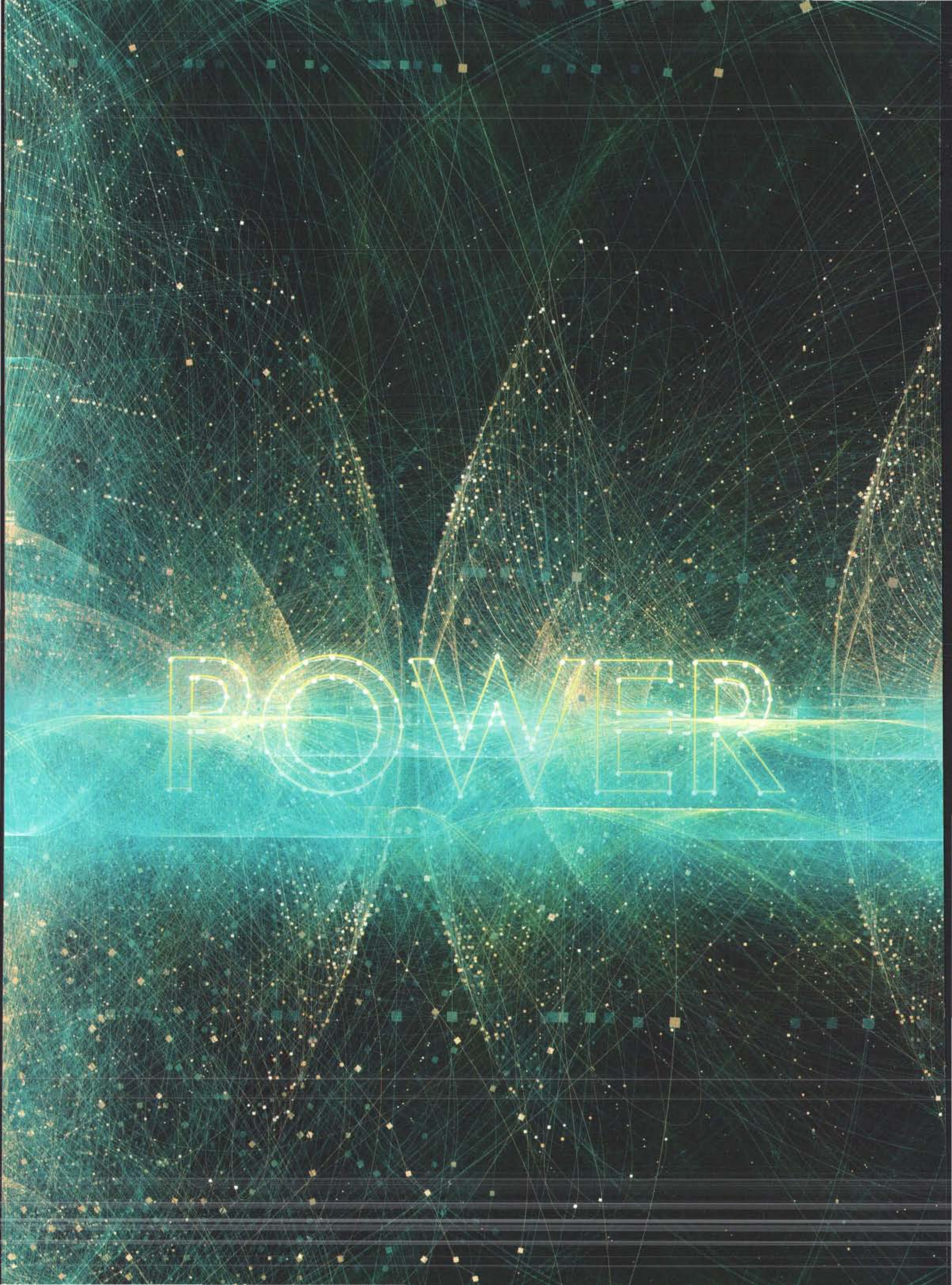
Spartan aesthetics aside, Swiss Fort Knox might be the most secure place in the world to spend a night. Have CEOs and celebrities got word of, and perhaps taken advantage of, Oschwald's unrivalled offering of privacy? To this, Oschwald can only say, "If that were true, I wouldn't be able to talk about it." What he could say, though, is that "Phil Collins is a friend of Fort Knox." And when, on our way to tour the rooms, we pass a hilariously out-of-place portrait of two Swiss military officials flanking none other than Tina Turner, Oschwald throws up his hands. "I can't really say more about that - she would kill me."

As Oschwald ushers us out of the hotel, we enter one last checkpoint. It empties us out into hallway of yellow doors, each numbered 3 and 4, depending on their security level. The "4s" are for clients who pay extra to bar anyone but themselves. Oschwald holds the door open to reveal what's inside: four massive clay-coloured metal safes.

"In one of these, and I won't tell you which one," Oschwald says, "is the digital genome time capsule." Sealed in wax, it awaits the next 50 years of human innovation in climate-controlled darkness. W

Ian Daly is a writer who lives in New York. He wrote about nuclear fusion in our 08.10 issue

ILLUSTRATION: SIAG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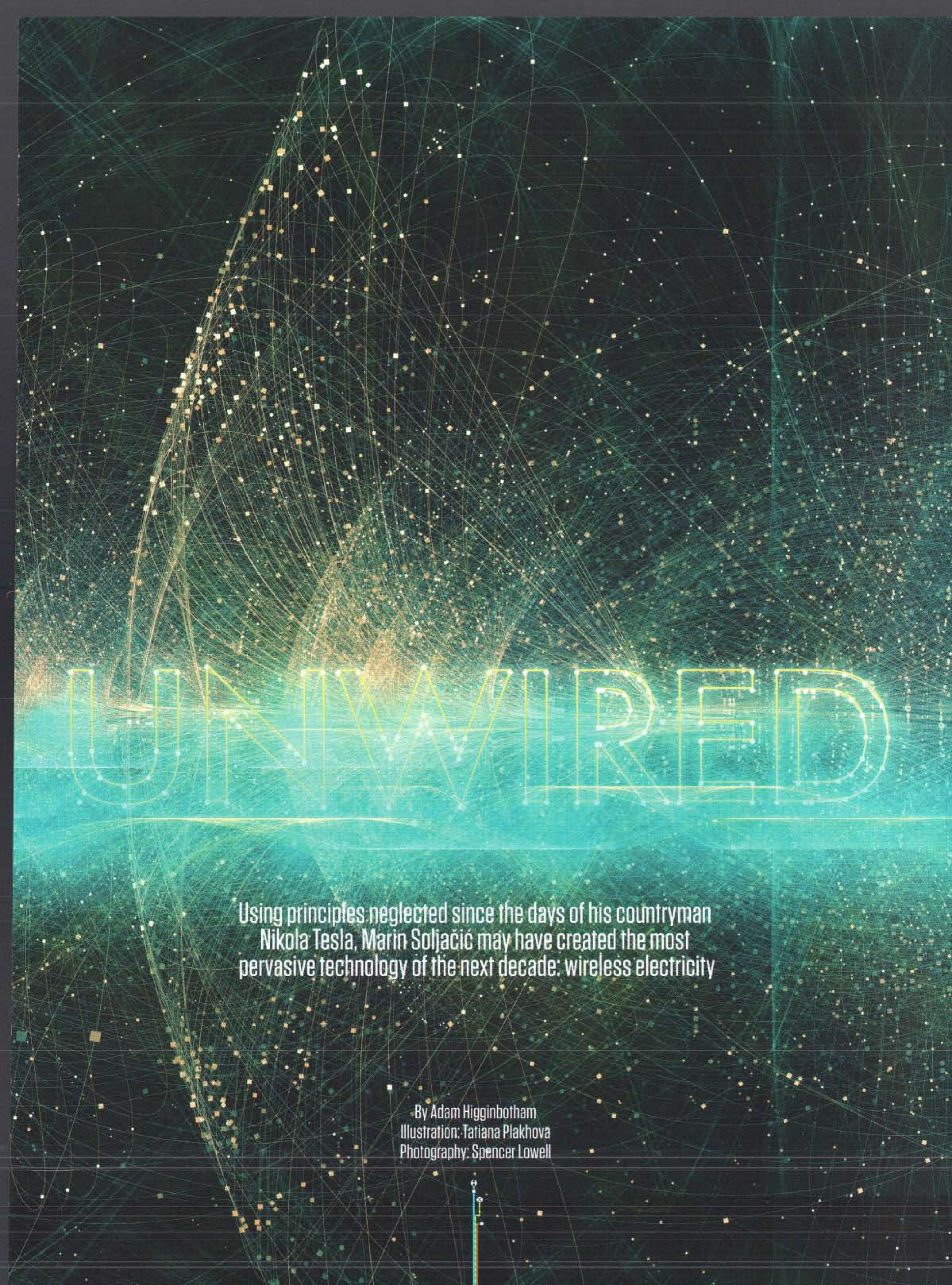
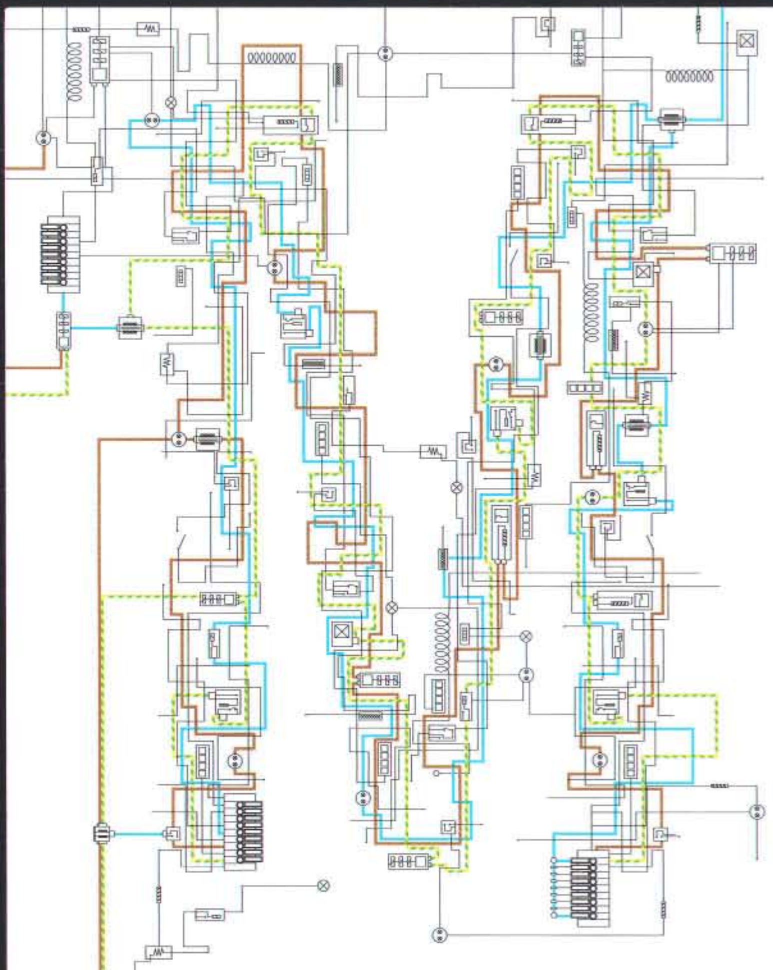


UNWIRED

Using principles neglected since the days of his countryman Nikola Tesla, Marin Soljačić may have created the most pervasive technology of the next decade: wireless electricity

By Adam Higginbotham
Illustration: Tatiana Plakhova
Photography: Spencer Lowell



arin Soljačić was awoken from a deep sleep in his suburban Boston home by persistent appeals for attention from his wife's mobile. It was not the first time it had happened: his wife often neglected to charge her phone, and when low on power it began to emit a loud and regular beep. Worse still, once in this state the device could not be turned off, and would be silent only when connected to a source of electricity. So Soljačić, then a 28-year-old Pappalardo Fellow in the Theoretical Physics Department of the Massachusetts Institute of Technology (MIT), often found himself blundering around the house in the early hours, searching first for the phone and then its elusive charger. "By that point," Soljačić says one June afternoon in his office at MIT, "you were, like, totally irate." Finally, at three o'clock one morning in 2002, a thought occurred to him: "Wouldn't it be great if this thing took care of its own charging?" Wherever it was in the house, the phone was usually only a few inches from a power outlet: what if it could take all the electricity it needed across that short space without a physical connection?

The next day, Soljačić began thinking about how to do this. As a specialist in optical physics, working in the field of nanophotonics, it was not an obvious problem for him to consider. But the terms of his fellowship at the time gave him unique latitude in his work. "You get paid, basically, for three years, and nobody asks what you are doing. The idea is that you have really talented and motivated people – they will produce the best stuff if you leave them alone."

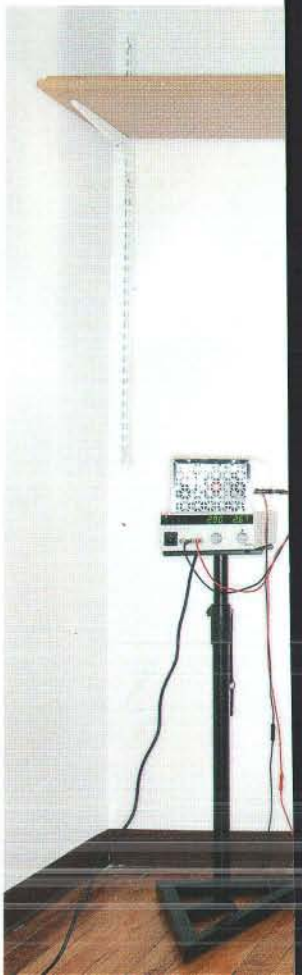
So Soljačić began research into which physical principles might make wireless transfer of power possible, and found that the relevant theories of electromagnetic phenomena were easily scaled up from his own apparently abstruse specialisation in nanophotonics. At first, wireless power was simply an amusing side project. "I wasn't devoting much time to it. Because, while it was fun to think about, I didn't know how you would make it practical," he says. But Soljačić soon involved his two close collaborators from MIT's electronics research laboratory and, in late 2002, the three men began their study in earnest. They would go on to spend another four years working on the problem.

During that time, they were frequently told that their task was impossible and, even once they had shown it to be feasible in theory, their science was widely held to be faulty. But in January 2007, Soljačić and a research team of two professors and three students conducted an experiment in which they successfully beamed enough power across two metres of empty space to illuminate a 60-Watt bulb. Using physical principles established more than a hundred years ago – but largely neglected since the days of Nikola Tesla and Thomas Edison – they had created what may prove to be one of the most pervasive technologies of the next decade: wireless electricity.

* * *

In the final years of the 19th century, few ideas would have seemed more extraordinary than the proposition that the world should one day rely upon a complex girdling of cables and wires to keep lights on and machines running across the globe. The pioneers of electricity could create miracles in the laboratory, but stumbled over a fundamental problem when they sought to make it practical. The places where electricity could easily be generated on the necessary scale – at Nikola Tesla's giant power station in Niagara Falls, for instance – were hundreds of kilometres from the places where it was most needed, such as downtown Manhattan. Edison proposed local power stations to provide electricity block by city block. Tesla – the Croatian-born Serb engineer credited with numerous discoveries in the field of electromagnetism, from alternating-current power to vertical-take-off aircraft – had a more visionary solution. He proposed long-distance wireless power transfer, using, among other ideas, the principles of electromagnetic induction, established by Michael Faraday in 1831.

These principles are at work in every electrical transformer, in which the magnetic-field-generated alternating current is used to transfer electrical energy across the narrow gap between two copper coils. At his laboratory in Colorado Springs, Tesla spent much of 1899 studying powerful high-altitude lightning storms, created his own lightning and succeeded in illuminating 200 light bulbs wirelessly from a distance of more than 40km.



An early demonstration model of wireless power transfer – now in Witricity's Boston headquarters

Later, at an experimental site on Long Island in New York, he built Wardenclyffe Tower, a mushroom-shaped structure that rose 60 metres into the air and contained a steel shaft running 36.5 metres into the earth below, encased in a timber-lined well measuring 3.5 metres on each side. It was apparently intended to transfer electricity wirelessly across the Atlantic. Exactly how Tesla planned to do this remains mysterious and only partially understood – not only were his ideas often decades ahead of his time, but he was also notoriously paranoid and secretive, and he deliberately rendered many of the details of his patents scientifically incomprehensible. But it now seems possible that he intended to use the resonance of the Earth's own magnetic field as a means of directing electricity from point to point through the planet's ionosphere in the form of giant lightning storms. Tesla ran out of funding before his experiments could reach fruition. Wardenclyffe Tower was never completed, and the partially finished structure was demolished in 1917 on the instructions of the FBI. Other scientists would dabble in the field, but the most realistic hopes for long-range wireless-power transfer died with Tesla in 1943.

"They couldn't have dreamed that people would love this electricity thing so much that they wouldn't mind dragging this vast infrastructure of wires into every single house, every single room on this planet," Soljačić says. The success of that infrastructure ensured that until recently little attention was paid to research into wireless-power transfer, and when it was, there seemed few practical applications for it. The few developments in wireless electricity that have been made since Tesla's time have used electromagnetic induction as a means for extremely short-range power-transfer, first as a way of charging electric toothbrushes and, more recently, in the wireless charging mats available for mobile phones and other personal digital devices.

'MARIN IS VERY MODEST. I'LL SING HIS PRAISES FOR HIM: HE'S A **GENIUS.** OFF THE SCALE'

But simple induction like this uses wireless power-exchange in exactly the same way as a household transformer: the gap between the charging and receiving coils must be tiny compared to their size, so the coils are so close together that they are almost touching. Once the distance between the two coils becomes larger than their individual diameters, the exchange of electricity between them ceases. As a result, although it is possible to separate the coils in a transformer to a distance large enough to exchange electricity wirelessly across, say, an entire room, it would require a mechanism with coils as large as a house to do so.

Yet Soljačić managed something that no one else had done before. "He figured out how to separate the coils in a transformer to a distance greater than their size and have it continue to work," says Eric Giler, CEO of Witricity, the company Soljačić has since founded to exploit his discovery. This breakthrough, which made it possible for the first time to contemplate truly practical wireless electricity, had been theoretically feasible for at least 40 years. And yet it had eluded generations of physicists and engineers. "Marin is a tremendously creative guy. This was just rethinking an old question with an open mind," says Douglas Stone, professor of applied physics at Yale University. "The theoretical physics involved is not advanced. This is just having an eye for a possibility inherent in electromagnetic theory that people had dismissed, and saying, 'You could probably do this.'"

"Marin is very modest," Eric Giler says. "So I'll sing his praises for him: the guy's a friggin' genius. Off the scale."

* * *

At 36, Marin Soljačić is now an associate professor of physics at MIT, where he divides his time between research and teaching undergraduates. He is faultlessly polite but his English is slightly

ILLUSTRATION: LUCY VERRECHIA

accented and occasionally idiosyncratic; he is notably fond of the word "funky". Born in 1974 in Zagreb, in the then Socialist Federal Republic of Yugoslavia – less than 200 kilometres from the tiny village now celebrated as the birthplace of Nikola Tesla – Marin Soljačić is the only son of two university professors, and the grandson of a renowned Croatian botanist. Inspired by the original *Star Wars* trilogy and Carl Sagan's *Cosmos* TV series ("I saw that entire series, watched it again and then got the book"), by the time he was eight he wanted to become an inventor. At 14, he knew what interested him most was applied physics. His love of the subject was crystallised by the enthusiasm of his high-school physics teacher: "She emphasised over and over again the excitement and the beauty of it all," he says, "and that's the real reason why we do it."

When war came to Yugoslavia in 1991, Soljačić and his friends prepared an escape plan in the event that Croatia might be swallowed by bloody conflict for years to come. At the suggestion of an older student at his school in Zagreb who had won a place at MIT, Soljačić made his own application in the autumn of 1991. By the time he received a reply the following year, the worst of the war in Croatia was over. "I got a letter saying, not only would they admit me, but they would pay for everything. At that point, it was like, 'What's the worst that can happen?'" He decided on a double major in physics and electrical engineering. Eighteen years later, he says, "I'm still here."

Soljačić was unaware of the long history of wireless electricity when he started his research in 2002. Only when he began a literature and patent search on the subject did he learn of Tesla's work in the field. At first, he considered using radio waves as a means of power transfer, but discovered that most of their energy dissipates into space. More focused methods such as lasers and microwaves – successfully used to transmit electricity by Nasa scientists in the 70s – would be more effective, but required a direct line of sight and could harm anyone in their way. But the use of magnetic fields could be both efficient and safe. Soljačić's work in photonic optics had led him to the phenomenon of electromagnetic resonant coupling, in which two objects tuned to the same frequency exchange energy very effectively, but have little effect on the objects around them. The analogy that Soljačić often uses to explain the theory (which was outlined in MIT *Technology Review*) is a room full of wine glasses, each containing a different quantity of water so that each one vibrates at a different acoustic frequency. When an opera soprano enters a room and begins to sing a note, only the one glass tuned to the frequency of that note will vibrate, as it absorbs the sound energy from the singer's voice. Eventually, the glass will absorb so much energy that it will shatter – but the other glasses remain unaffected.

HE WAS INSPIRED BY THE FIRST **STAR WARS** TRILOGY AND CARL SAGAN'S **COSMOS**

Soljačić thought that in this way it might be possible to couple two objects using resonant magnetic fields, and use the link thus created to transfer electricity. Over a period of months, he began to formulate a coherent theory. "It was, like, spinning in the back of my head," he recalls. "You have a feeling, 'Yeah, maybe that could work – but how, exactly?'" By 2005, he had worked out the fundamental concept, and was optimistic that what he called the "strongly coupled resonances" of low-frequency magnetic waves could be used for wireless power-transfer. In October that year he gave a presentation on the theory at Amazing Light, a symposium held in Berkeley,

ILLUSTRATION: REMIE GEOFFROI

California, to celebrate the 90th birthday of Charles Townes, the inventor of the laser, and attended by 21 Nobel laureates. He won a young scholars' prize for the presentation, awarded by future US Energy Secretary Stephen Chu. Chu's excitement about the idea of wireless power encouraged Soljačić – who was under no illusions about the abstract nature of most of his work – that this was something that could capture the public imagination.

"You know, a lot of things that we do are not so easy to communicate," he says. "But this one I can explain in 30 seconds, to most people, why it is important." For the first time since he had started, Soljačić began devoting the majority of his days to work on wireless power. By the time he was invited to deliver a talk on the theory before the American Institute of Physics in November 2006, he had devised a possible practical embodiment of his theory. Calculations and computer modelling suggested that two separate metallic coils could be used as the instruments of the magnetic coupling. "It seems," he thought, "like this should really work." But he and the team had not yet conducted any real-world experiments. "He did the math, and it worked," says Eric Giler. "The difference between physicists and engineers is that physicists believe that if the mathematics work, it will work."

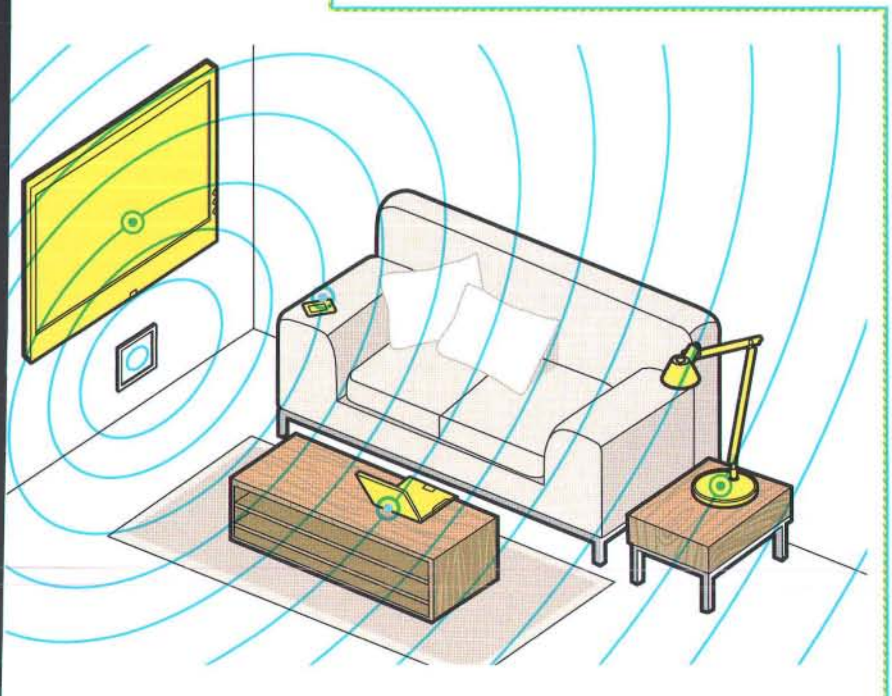
Soljačić's presentation created a deluge of interest from the media, and calls came into his office from around the world. Yet when he attempted to have his findings published in full, his paper was turned down by almost every scientific journal he sent it to. "It was rejected from *Science*, it was rejected from *Nature: Physics* – it was even rejected from *The Journal of Applied Physics*," Soljačić says. "Some people said, 'This is impossible'; some said, 'We don't believe you'; and one even said, 'I don't see an application.'"

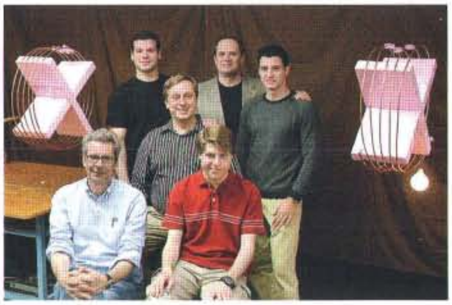
Marin Soljačić in his Boston offices, near MIT, which he joined in 1992. Eighteen years later, "I'm still here"

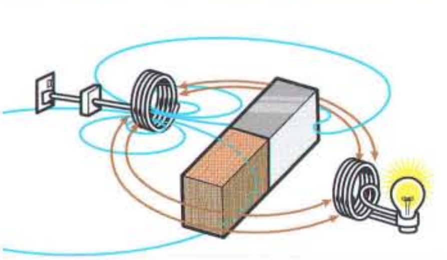
Eventually, the paper was accepted by a relatively small specialist title, *The Annals of Physics*, but even it turned out to be in no hurry to publish. At MIT, Soljačić and his team raced to prove their theory with a successful experiment. They gathered equipment and components as quickly as they could, buying copper tubing on eBay, and even scavenging an inductor from a microwave oven one of Soljačić's students found being thrown out of his dorm. They bent the tubing into two 60-centimetre-diameter coils, forming five complete turns around cross-shaped blocks of polystyrene building insulation bought from Home Depot, and suspended them from the ceiling of their lab with lengths of fishing line. To one coil they attached a 60-Watt light bulb; the other was fitted with a connection that led to the mains. A distance of two metres of open space separated the two coils. Although Soljačić had the utmost confidence in his theories, he had always intended his invention for mass production. It was not enough for the experiment to work: it had to demonstrate that the technology might work reliably, and well. He anticipated hitches and problems. "There are limits to theory, right?" he says.

But on January 15, 2007, they turned on the mains connection, and the experiment worked just as Soljačić had predicted in his equations. The bulb lit, and stayed on, receiving electricity from the transmitting coil with around 50 per cent efficiency. "That was truly remarkable," Soljačić says. The light stayed on even when they introduced a wooden board into the space between the coils. In the photograph (*below*) taken of the team that day, the six men pose, grinning, in the two-metre gap, right there in the middle of the strongly coupled, resonant, low-frequency magnetic fields, with the light bulb glowing: testament to their confidence in the safety of Soljačić's device. "Everybody was very happy," he says, "and very fantastic."

Today, Marin Soljačić's original experimental equipment languishes in a windowless storeroom at the Witricity offices, a bland warren of cubicles housing 22 employees on the second floor of a large brick building in the Boston suburb of Watertown. "So this," Giler tells WIRED one







Top: Soljačić (*centre*) and team on the day they first demonstrated wireless electricity. *Above*: a schematic showing magnetic coupling in action morning in June, as he tugs a dusty block of polystyrene free from a pile of empty cardboard boxes, "spawned an industry."

Even before *Science* finally published his findings in June 2007, Soljačić had begun receiving thousands of enquiries about the potential exploitation of the new technology. Some were predictably outlandish – one individual wondered if the problem of providing electricity to the remote islands of Indonesia could be solved wirelessly ("You look at the map: it's like half of the Pacific Ocean. And you're like, 'No, no. We can do it over two metres; we're not quite there yet'," says Soljačić); another suggested the physicist may have stumbled upon a principle to explain telepathy. But among the dreamers and crackpots were at least 500 potentially profitable propositions. These, Soljačić says, "encouraged us to start a company that would then figure out, well, what makes sense commercially."

With the support of MIT, Soljačić founded Witricity soon after completing his first conclusive experiments and began registering patents before any details of the technology were publicly disclosed. In exchange for giving royalties and a small equity stake in the company to MIT, Witricity now hold the rights to at least 125 published patents in the commercial field they established, with more potentially to come.

* * *

Giler was hired as company CEO in August 2008. A loquacious graduate of Harvard Business School and veteran of tech start-ups, Giler, 54, has a thick head of greying hair and a bushy moustache, and retains a slight limp from injuries sustained in an accident he had earlier this year, while on a transcontinental motorcycle trip across Australia. Giler made his fortune with a telecoms operation he started in 1984, and had already briefly experimented with retirement – for six months – before he agreed to join Witricity. He was so impressed with the idea of Soljačić's technology that he agreed to start without even seeing it work. His strategy is to sell its inventions into as many applications as possible: "Either licensing the technology or manufacturing components," he says. "You make a little money off a lot of people. Anything with a cord on it, anything that uses a disposable or rechargeable battery – all of those are candidates for going wireless." One of the first steps was to demonstrate it in public, in an obvious and practical way.

In January last year, at the giant Consumer Electronics Show in Las Vegas, Giler unveiled an entirely wireless TV set, built in collaboration with the Chinese electronics corporation Haier. Haier provided a TV set already equipped to receive wireless data from a DVD player, and Witricity added a pair of resonant coils. It deliberately concealed the mechanisms in black plastic casings resembling empty picture frames – one, attached to the back of the set, was about 45cm by 50cm and the other, mounted on a stand 1.2 metres away, was a little larger. Rather than take at stand at the trade fair, Giler booked a hotel room and invited the heads of major consumer-electronics companies to see him demonstrate what they had built. "We just said, 'Hey, if you could do this, would this be interesting?'" Giler, unsurprisingly, found that many of the executives were very interested. When, as part of a similar presentation at TEDGlobal in Oxford six months later, he plugged the transmitting coil in to the mains and flicked on the wireless TV by remote control, the audience applauded. "Its almost magical," Giler says, "the way that it works."

Giler says the first question he's typically asked about the technology is almost always about whether it's safe, and he has a ready answer: resonant coupling creates magnetic fields, not electrical ones, and these are relatively weak – comparable to the strength of the ones we already live in, created by the Earth. An MRI machine generates a magnetic field around a million times denser than any Witricity device. "All the systems we've designed are well below the maximum permissible limits for human beings," Giler says. And one of the notable characteristics of fields of magnetic resonance is that almost all objects not tuned to their specific frequency – walls, animals, human beings – are essentially invisible to them.

* * *

The second question Giler is usually asked is, "How small can you make it?" This was the first obstacle to making wireless electricity a commercially viable proposition, and a major technical challenge. Giler shows me a series of devices equipped with wireless resonators: a TV and DVD player, a video projector, a laptop, a rechargeable cordless drill fitted with a torch attachment. When the receiving coil built into each one is brought within a metre or two of a source coil – "They don't have

Witricity's wireless TV set, which provoked applause when it was unveiled at TEDGlobal in 2009

to be the same size, and they don't have to be pointed at one another. They just have to have their fields intersect," Giler explains – the device flicks into life. But in his initial demonstrations, these resonators had to be connected to a large rack of equipment, including a frequency generator, an amplifier and power monitors. Despite the apparently simple effect created by the intersecting magnetic fields, the technology required to keep them linked is complex, because they must be tuned to the same frequency: "And the frequency has to be maintained perfectly," says Giler. "If you start to move, if you add metal – your keys – if you move things around in the environment, the frequency will start to detune." So, to make them work outside a lab, each coil must be accompanied by hardware and software that adjust the frequency automatically to maintain the resonant effect; combining all of these elements in a package small enough to be embedded in pieces of consumer electronics took 18 months.

TYPICALLY, THE FIRST **QUESTION** THAT PEOPLE ASK IS, **'IS IT SAFE?'**

In a second demonstration room, Giler shows me a mobile phone equipped with a wireless coil, and the source-resonator package required to charge it: the hefty rack of equipment used at TED has been reduced to a chip and a printed circuit board a few centimetres square, mounted beneath a desk and powered from a USB connection. With this, he explains, they have "energised" the surface of the furniture. Anything placed on or near it, up to 45 centimetres away – including, for example, a mobile phone suspended amid the contents of a cluttered handbag – will begin charging, "because the magnetic field is going all around the surface of the desk." When I ask Giler about the most surprising reaction he has had to one of his demonstrations, he picks up a Witricity-equipped charging mat for phones and PDAs, and holds it against the small of his back. In his other hand, he takes a battery-powered LED light. "I guess if you like that movie *Iron Man*..." he begins, and presses the light against his chest. It glows brilliantly, as if he has flicked a switch. "That's when people are the most surprised," he says.

In the three years since Soljačić's first successful experiment, wireless electricity has become a competitive market. Companies including Wildcharge, Powercast, Powerbeam and Fulton Innovations are all either selling or about to sell wireless products. But many of these products have a very limited scope. Wildcharge's charging mats use conduction, which may be wireless, but still requires a physical connection with the device. Powerbeam uses laser diodes and photovoltaic cells to provide optical connections between lamps and picture frames, but requires clear lines of sight. Powercast "harvests" ambient radio waves to power ultra-low-voltage devices, such as LED floor tiles and Christmas ornaments.

The battle for space in this crowded market has led to several disagreements over the merits of the competing technologies. Last year, a senior member of Powercast's management described the doubts aired by Fulton Innovations' David Baarman about whether radio-frequency technology could be dangerous around electric wheelchairs and pacemakers as "competitive drivel", adding, "Baarman has been saying this for a couple of years, because what we do will eventually replace what he does." Fulton, where Baarman is director of advanced technologies, is a division of direct-sales behemoth Amway, and markets eCoupled, an induction-based series of devices. The company has developed experimental products with Bosch and furniture manufacturer Herman Miller, and is a member of the Wireless Power Consortium, a trade organisation seeking to bring a global standard to wireless-power devices.

Yet the applications of induction have been regarded as limited because it requires such careful positioning and close proximity of the devices – unless the induction coils used are impractically large. "There are great applications for inductive technology, if alignment and distance aren't an issue," Giler says. "But if alignment and distance are an issue, that's when you want to use what we're doing."

David Baarman, an engineer who has been working on induction products for Amway since 1997, disagrees. He says that its induction devices are viable over comparable distances to those of Witricity: "We can do metres," he says. He believes that his work essentially duplicates that done at MIT, and suggests that there is little new about Soljačić's invention: "If you look at one technology versus the other, it is extremely similar, and that's why we really like our patent portfolio and really like our position," he says. "If you look at one of the first patents that was granted from MIT, we're cited pretty heavily." Giler breezily dismisses such claims as technical obfuscation and, following my conversation with Baarman, an eCoupled publicist writes to clarify further: "It's a little sensitive around some legal areas and it's not our style to criticise our competitors – there's probably room for everyone in this market."

Elsewhere, in the Seattle research labs of Intel, principal engineer Joshua Smith has been working on wireless-power technologies since 2004. He recently created low-power devices including clocks that run by harvesting the ambient energy broadcast by TV transmitters. Like many of the R&D departments of the world's major corporations, Intel's began working on strongly coupled resonance devices after reading the MIT paper. And it hopes to develop the technology: "We're thinking in terms of laptops and mobile phones – charging phones seems to be what people really want," Smith says.

But although the explosion in the number of battery-operated personal digital devices – phones, iPods, laptops and cameras – provides the most obvious immediate market for Witricity's technology, Giler promises that there will be many more. "The highest degree of interest we've had are at opposite ends of the power spectrum: mobile phones and cars," Giler says. He will not name specific motor-industry partners, but the company's chief technical officer, Katie Hall, explains that Witricity has developed high-power mats that can be buried beneath a parking space or rest on the floor of a garage and begin wirelessly charging the batteries of electric cars as soon as they've stopped. These devices are the highest-power application Witricity is working on, and transfer 3.3 kiloWatts – enough to charge a car overnight. In the future, it may be possible to do away with batteries altogether and build the power infrastructure into the actual roads, allowing cars to run like electric trains. "Imagine if you could just hop from coil to coil," Giler says. "You put little coils in the road or in the guardrail or streetlamps."

Witricity has also been approached to develop the technology for the oil industry – for example, to replace the fragile wires used to send information back to the surface from sensors near the end of deep-drilling bits – and for defence applications, to power remote sensors and provide charging for bomb-disposal robots. But one of the most potentially far-reaching applications lies in medicine, where wireless electricity could help make electrically operated implants long-term-safe solutions for pain relief and chronic illness. Ventricular-assistance devices that help heart-disease sufferers who do not qualify for transplants, for example, are often powered by implanted batteries with a limited life, or by external battery packs connected to a wire passing through the skin. "People die from infections from the battery lead," Giler says. A resonating coil could recharge a battery implant simply by having the patient sitting in a chair for a short period every day.

The main obstacle to more widespread applications is distance. As the coils move farther apart, the efficiency of the power transfer gradually drops: at a 30cm range, a 45cm coil is more than 95 per cent efficient; at 2.3 metres, that falls to ten per cent. Although in theory there is no maximum range across which the transfer can take place, once efficiency drops below ten per cent it becomes impracticable. "We usually say the technology is suitable for things in a room – that room could be the inside of a car, a garage," he says.

But Witricity has already made progress in extending the range across medium distances using passive resonators. These inert devices pass the energy between two resonating coils – one example Giler demonstrates is a flexible sheet of plastic shelf paper containing a copper-based resonator less than two millimetres thick, with a chip attached, which he uses to line a kitchen cabinet. The sheet creates a power bridge to a coil plugged into the wall socket below, energising the entire cabinet for wireless lighting. Embedded in flooring or beneath carpets, passive resonators could make it a simple matter to create an entirely wireless home.

Giler, naturally, sees things going even further. "In five years' time, this conversation will seem quaint," he says. "In ten years' time, I

LOOK, NO CABLES

WILDCHARGE
This technology uses mats to charge devices by conduction: they need to be in direct contact with the metal strips in adaptors for iPhones and BlackBerries.

FULTON ECOUPLED
Fulton's device uses induction mats to power enabled devices. It is working with a furniture company to build its devices into objects such as tables and chairs.

PRIMOVE
Transport manufacturer Bombardier developed this system to power trams and trains wirelessly, using inductive coils under tramlines and in the trams themselves.

LASERMOTIVE
This uses a high-powered infrared beam to transmit power. It was the first winner of Nasa's Beam Power Challenge, pushing a 4.8kg weight up a 900m cable wirelessly.

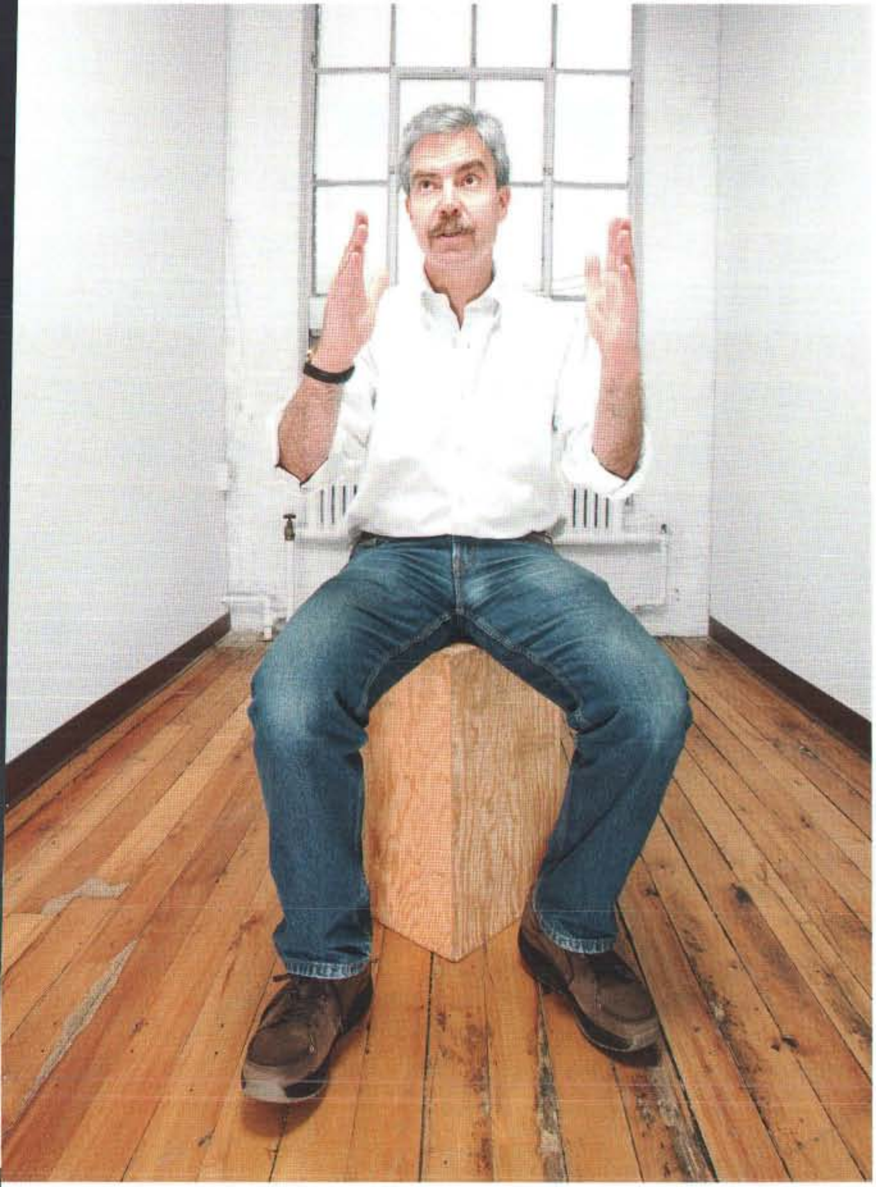
WREL
Intel's demo video shows sound and power being transmitted wirelessly to a speaker at the same time, though the product is several years off being commercially available.

RCA AIRPOWER
RCA's device debuted at CES 2010. Slated for a winter release, it promises to charge devices by harvesting the energy of ambient Wi-Fi signals.

like to think we'll have broken the distance barrier. It will make a whole host of things possible that weren't possible before."

Soljačić's recent research suggests it will eventually be possible to realise at least part of Tesla's dream of long-range power transfer, and send wireless electricity over a distance of kilometres. "You create an intermediate resonant object that functions as a way that you could couple energy from here, to there, to there, without energy actually ever existing in the interim object," Giler explains. Witricity has already applied for a patent in this technology, and even given it a name: "We call it the Dark State," Giler says. He claims that the Dark State would make much of the wired infrastructure that now passes beneath our feet or over our heads entirely unnecessary. "Or significant portions of it would not be done in the same way. We'd probably need some way to get energy over very long distances – but there are other ways to do that." For the time being, the Dark State remains purely theoretical. "But what Marin did before was impossible, too," says Giler.

Although Soljačić and the technicians at Witricity may not yet have built a mechanism to generate the Dark State, Giler remains confident that they will. "The maths works," he says.



The gap the electricity travelled was this big: Eric Giler become Witricity's CEO without even seeing a demo

In September 2008, in recognition of his work in optics and the development of magnetic resonance, Marin Soljačić was selected as a recipient of one of the MacArthur Foundation's "genius" prizes. Awarded every year to 25 individuals who are each deemed leaders in their respective fields, recipients of a MacArthur Fellowship are paid $500,000 "with no strings attached".

As we leave MIT one afternoon in his shabby-looking Toyota Corolla, Soljačić says that he hasn't yet spent any of the money. He's keeping it to fund further research. "There are some things that are kind of far-out ideas that it's not so easy to get money for," he says. What do you think you'll spend your first million on? "Good question! People ask me, 'So you gonna buy a new car?' I'm like, 'There's nothing wrong with my car.'"

He allows that he and his wife like travel, so, if Witricity takes off, they may take a cruise.

"This consumerism and materialism is... there's no point to it, right? What I've found is, at some point it's better to say, 'It's enough.' You can focus on other things in life, like maybe making somebody else happy, that needs this money more than I need a Lamborghini, right?"

Ultimately, the commercial success of the technology will hinge on how widely adopted it turns out to be, and whether Witricity – or one of its competitors – is adopted as a global standard. "It's certainly potentially revolutionary and it's a great creative idea," says Stone. "We're on the wave, we don't know where it's going to go – whether it's going to be just something very creative but niche, or if it's going to be pervasive technology."

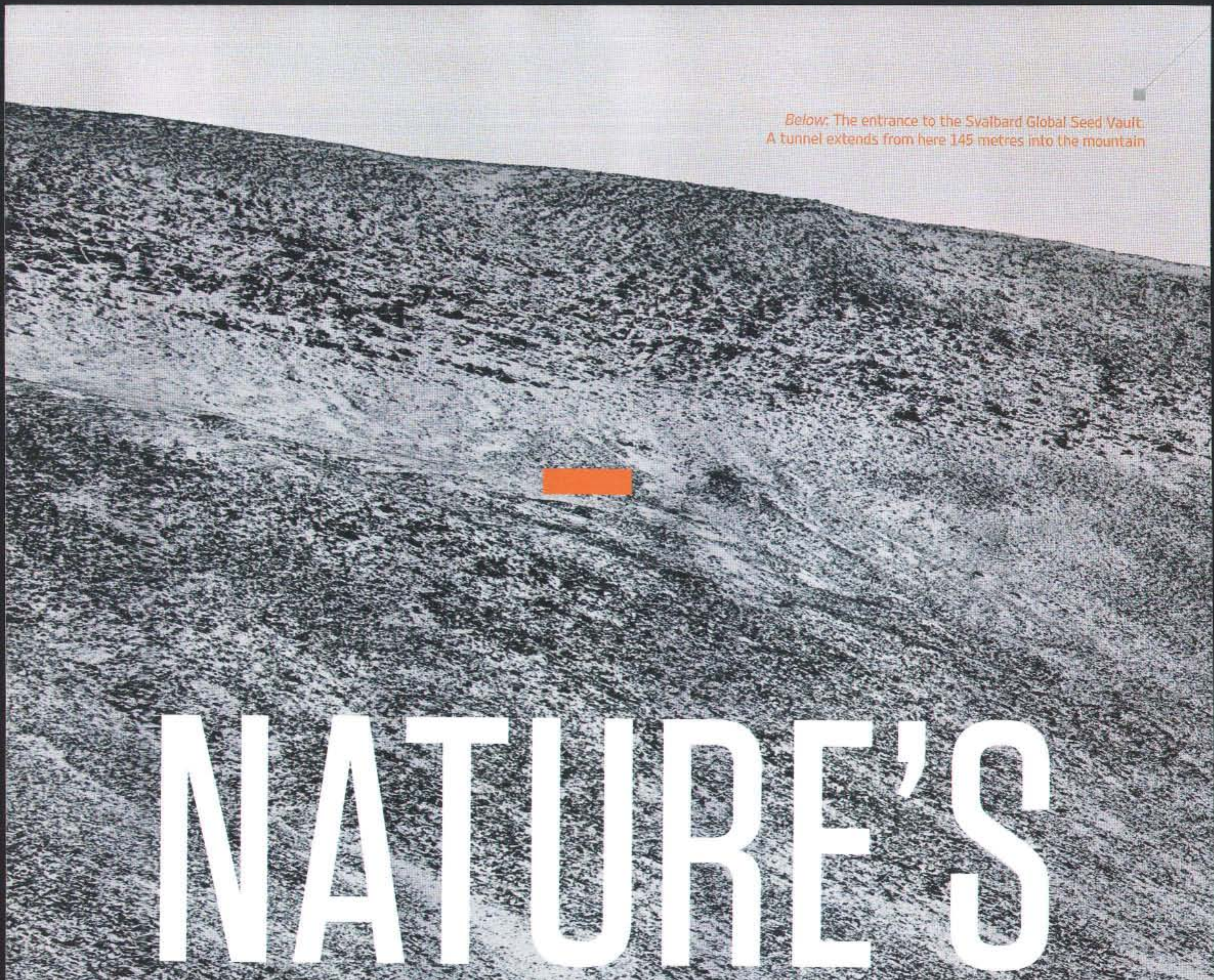
Soljačić himself won't be drawn on how significant a breakthrough wireless electricity might be. "I have very high hopes for it and high expectations, but you can only answer a question like that 20 years from now. When the semiconductor was invented – which led to microelectronics – what they were trying to develop was an amplifier for a smaller hearing aid. And now it's one of the most important discoveries, right?"

Eight years after her phone first bothered him, he has still not provided his wife with wireless charging. "She does keep asking me every month, 'So... when can we get this thing?'"

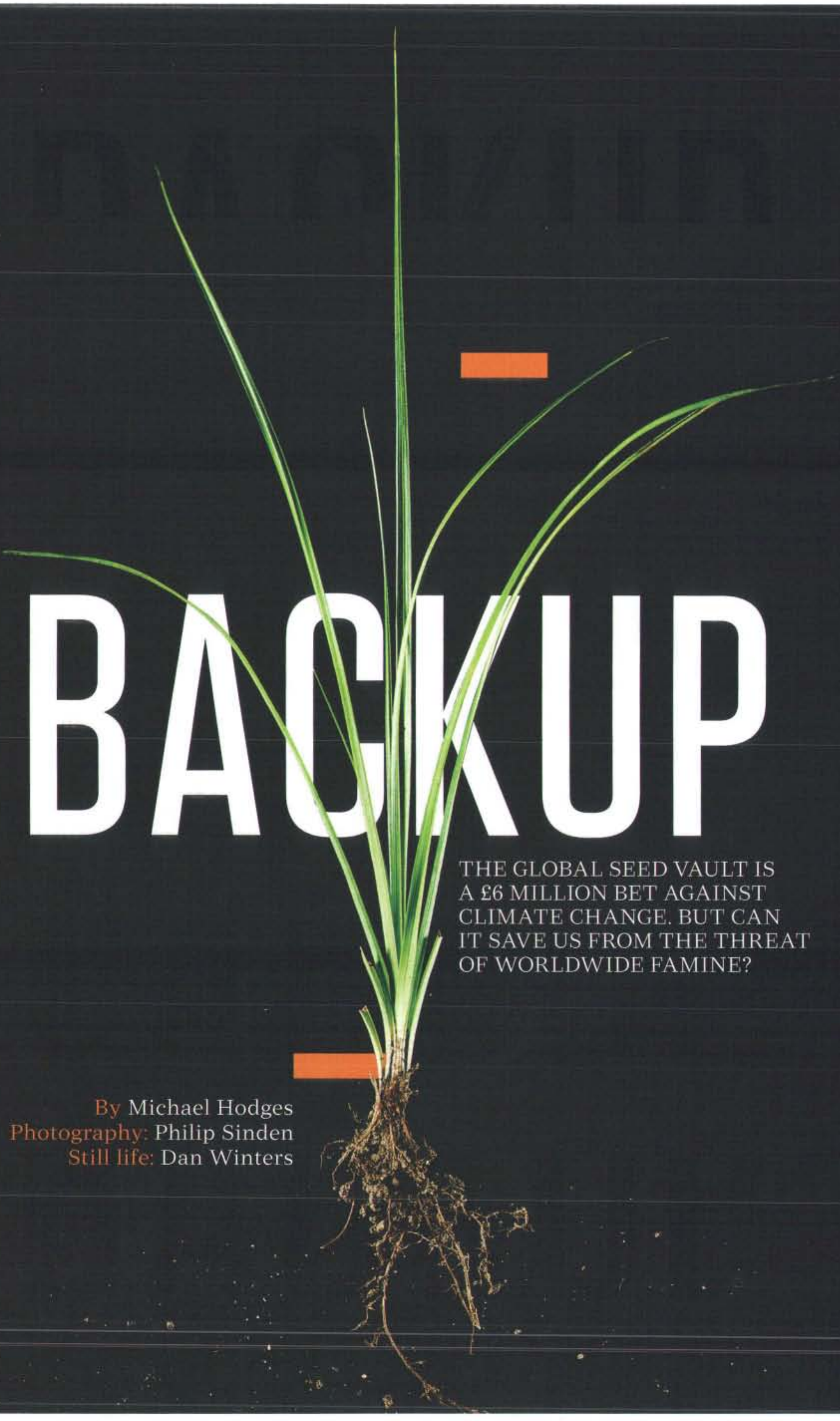
And is it still waking him up at night? "Interestingly enough, she doesn't forget to charge it any more," he says, and laughs. "We've been married for a long time, I guess."

Adam Higginbotham is a writer based in New York. He wrote about defusing IEDs in 09.10

NATURE'S



Below: The entrance to the Svalbard Global Seed Vault. A tunnel extends from here 145 metres into the mountain



BACKUP

THE GLOBAL SEED VAULT IS A £6 MILLION BET AGAINST CLIMATE CHANGE. BUT CAN IT SAVE US FROM THE THREAT OF WORLDWIDE FAMINE?

By Michael Hodges
Photography: Philip Sinden
Still life: Dan Winters

A GANGLY 60-YEAR-OLD AMERICAN STANDS IN FRONT OF A STARK CONCRETE WEDGE ON THE SCREE-LITTERED SLOPE OF A MOUNTAIN DEEP IN THE ARCTIC CIRCLE. THE ARCHITECTURE IS ABSTRACT, THE SURROUNDINGS BLEAK AND WINDSWEPT. YET THE CURLY-HAIRED MAN IS ANIMATED. "THERE IS A PASSION AND INTENSITY IN THE WORK WE ARE DOING HERE, AN ALMOST RELIGIOUS FERVOUR," SAYS CARY FOWLER. "BECAUSE WE UNDERSTAND WHY PRESERVING BIODIVERSITY IS SO VITAL."

Fowler's remit, as executive director of the Global Crop Diversity Trust, is "to ensure the conservation and availability of crop diversity for food security worldwide". Or, more bluntly, to stop the world from starving as its crop varieties lose the ability to adapt to climate change. So, 1,000km north of the Norwegian mainland, Fowler's trust is storing the seeds of varieties that may be able to overcome the new conditions. "The work we are doing under here will save diversity that will otherwise become extinct," he says. "That's why it feels so good to walk into this vault. The seeds we store in here are not lost, and that will literally save millions of lives. The alternative is unimaginable – what do you get if you lose your biological foundation?"

And with that he pulls open the steel door and enters the Svalbard Global Seed Vault – an almost unfeasibly remote outpost engaged in the vital business of preserving humankind's ability to put food on its plate.

The Global Seed Vault opened in 2008 after engineers spent a year drilling and blasting through the sandstone, siltstone and claystone of Platåberget Mountain to create a system of subterranean chambers on the Advent Fjord's southern flank that could store 4.5 million seeds. The $9 million (£6 million) construction costs were paid for by the Norwegian government, which also contributes a $150,000 annual grant. The trust – a UN-affiliated body funded privately and by donations from sovereign states (including the UK) – meets other costs and runs the vault, which is why Fowler is in Longyearbyen today. A spectacled, rangy American with tight curls of reddish hair, he has an air of distraction coupled with sudden enthusiasms that suggests a powerful yet abstract intelligence. But he is also supremely practical – as he needs to be, concerned, as he is, with the survival of the human race.

The threat to food crops from climate change is alarming scientists. "At a recent conference I attended, forest geneticists were predicting that we have already moved seed zones [the altitude bands in which individual plant species thrive] up one zone in the past 50 years," says Dave Ellis from the National Center for Genetic Resources Preservation in Fort Collins, Colorado. "This is truly astonishing." The band shift shows that higher elevations are getting warmer, affecting which plants can grow there. The Seed Vault offers at least a backup option. "Svalbard is vital to global efforts to preserve the genetic variation found in our crops and their wild relatives," says Tim Wheeler, professor of crop science at the Walker Institute for Climate System Research at the University of Reading, and one of the UK's pre-eminent experts in the field. "Maintaining this genetic diversity for use in crop-breeding programmes gives us another option in tackling major challenges to our food crops, such as from pests, diseases and climate change."

When the vault opened, media coverage suggested that its mission was biblical – Fowler was a modern-day Noah saving plants rather than animals – or focused solely on the building: the vault as the lair of a James Bond villain. "It would be kind of neat if they did film one here," Fowler says wryly as we leave the airport. "I'd like to meet the Bond girls."

He got used to what he calls "the usual corporate con-

spiracies. The claim that we're going to put half of the Norwegian population in the vault, wait out a cataclysmic event and then repopulate the world," sighs Fowler. "Half the population. That's two-and-a-half-million people. There's only one chemical toilet."

Right: This far north, seeds will survive even a power failure

He laughs, but the doubters pain Fowler. "People all over the world are packaging up their seeds and sending them here for us to conserve," he says. "We are solving a problem, and I think it is a commentary on our times that some people can't imagine that something good and positive is going on."

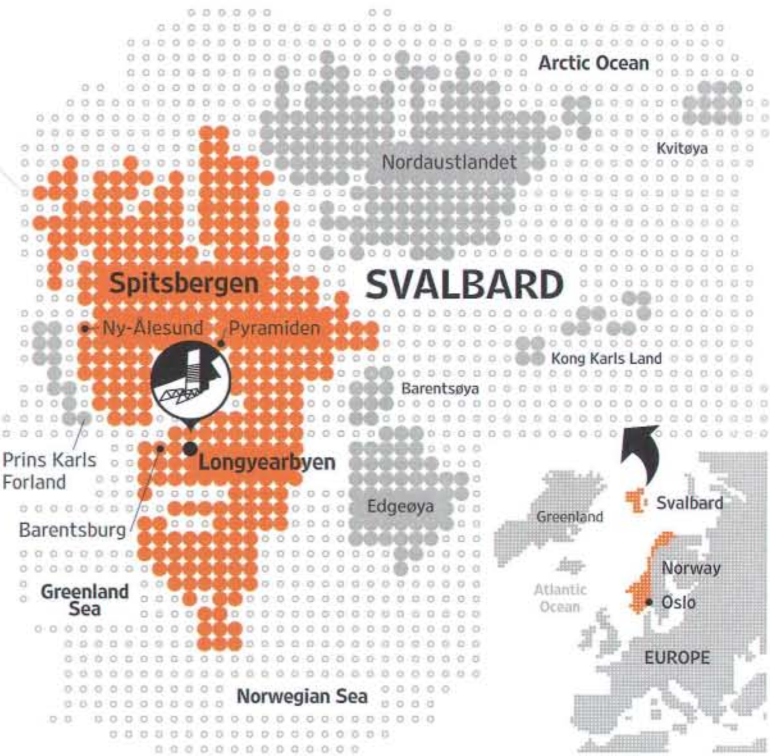
The Global Seed Vault is not intended to be a "Doomsday" plan, ready to replant the world in the event of a major disaster (although with the seeds of 526,129 crop varieties now safely stored, it could go some way to fulfilling that role). Instead, it operates as a secure storage space for samples of other collections that are at risk. The samples remain at all times the property of the depositors, the only proviso being that the originals must be freely available to researchers and breeders under the terms of the International Treaty on Plant Genetic Resources. There have been deposits from every continent: 3,710 species in total, from 29 crop institutes representing 226 countries.

Over the past few years the need for a secure storage facility has become ever more urgent. A typhoon in the Philippines in 2006 caused a flood that left the national crop gene bank under two metres of water. "And," adds Fowler, "war in Rwanda, Burundi, the Solomon Islands, Iraq and Afghanistan has destroyed seed collections – and the Pavlos station in St Petersburg, Russia's biggest field collection, is threatened by property developers."

Ruaraidh Sackville Hamilton, head of the gene bank at the International Rice Research Institute, also in the Philippines, makes the point graphically: "Our facility is earthquake-proof to force seven, bomb-proof, typhoon-proof, flooding-proof, with multiple backup power supplies, and our seed-handling and storage procedures are designed to keep rice seeds alive for 100 years," he says. "But what if we have a force ten earthquake? What if the dormant volcano three kilometres away erupts and buries us? We will lose our facility." More prosaically, diversity tends to be eroded in far less dramatic ways – a seed bank's power supply failing can be enough to lose a variety.

The disappearance of biodiversity is a slow-motion crisis: it's not the big bang of a nuclear bomb, but rather a gradual process that has the potential to be devastating. How much have we lost already? "We can't say," Fowler admits. "We didn't know for sure how much we had in the first place. But we lose something every day. The public is aware of the loss of a species, but not diversity within a species. Why do things become extinct? There is habitat loss, yes, but also when a species has lost its ability to evolve to meet new conditions. Agricultural survival is in our hands. We chose crops and

Left: Cary Fowler: "The seeds here will literally save millions of lives"



To reach Longyearbyen you must fly on the world's most northerly scheduled air service. But, at 78°N, most things in the Svalbard's largest town are the world's most northerly, including its church, university campus, bus station, bank, kindergarten, art gallery, cinema, shooting range, supermarket, cashpoint, taxi office, pub and kebab van. During the nightless months from April 19 to August 23, the vista of mountains, fjords and glaciers that greets the traveller arriving on the 62,049 square kilometres of the largely uninhabited Svalbard archipelago is spectral and otherworldly.

A day after WIRED arrives, a group of US senators and congressmen step from a Boeing C-40 bearing the words United States of America in blue along its white fuselage. They are the biparty Commission on Security and Co-operation in Europe (COSCE), the US governmental body tasked with assessing human rights, security and military issues, and climate threats across the 56 states that signed the 1975 Helsinki Agreement. They have brought a box from the National Center for Genetic Resources Preservation – part of the National Germplasm System operated by the US Department of Agriculture – that contains the seeds of 537 varieties of 13 food crops.

Among the samples are the seeds of three chilli plants: Wenk's Yellow Hots, Rooster's Beak and San Juan "Tsile". The Americans take a clear delight in delivering a source of hot food to one of the coldest places on Earth (in February it's -23° Celsius). "It protects diversity of food and food security," says senator Benjamin Cardin, the commission's cochairman. "It is very important for international security."

When approached along a track that dog-legs up a mountain, there are no armed guards outside the vault, just a concrete entrance that

Above: Mexican wheat sent to the Seed Vault by collectors in Delhi

resembles the monolith in *2001: A Space Odyssey* – a stark, grey portal that is simultaneously ancient and futuristic. On the roof above the portal there is an artwork called *Perpetual Repercussion* by Norwegian artist Dyveke Sanne, a light-box containing triangles of highly reflective, acid-resistant steel, set in a ten-centimetre-deep glass niche, alongside prisms and mirrors. It casts a flickering, abstract pattern across the snow-clad slopes of Platåberget during the perpetual darkness of winter. Once inside, however, the Global Seed Vault is robustly utilitarian. "Essentially," Fowler explains, "it is a long corridor with a very cold room at the end."

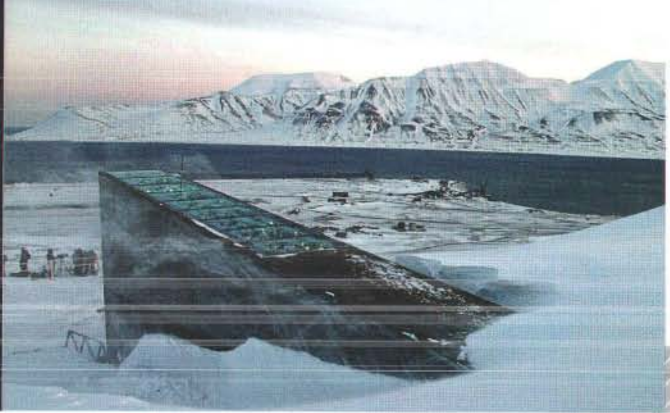
Beyond the portal the concrete walls and floor angle down to another doorway, which leads to the "Svalbard tube" – a dipping enclosure of corrugated steel, its compacted earth-and-Tarmac floor iced over. Meltwater from the mountain gushes along the edge of the walkway. We walk through a second doorway into a service area. Above us racks and conduits take lights, power lines and ventilation ducts into the vault. To our right a single-storey cinder-block construction contains two offices. We pass through another entrance and into the main cavern. Immediately the temperature drops. We are in the permafrost. This is Fowler's favourite area. "I think of this as a cathedral," he says, gesturing at the jagged white walls that have been carved from inside a mountain.

He points to the wall opposite the entrance. "We made a bowled area in the rock face. If someone fired a rocket straight down the entrance, or a nuclear blast came along the corridor, it would hit the bowl," he says. "After that there is only one place it can go – back out where it came from." A work by the Japanese artist Mitsuaki Tanabe hangs at the centre of the blast deflector: *A Seed of Wild Rice – MOMI 2008*. Sculpted from stainless steel, it represents "the mother of all rice".

Three doors lead off to subchambers but only the central one is occupied. Inside, the temperature (presently -18°C) is kept low by a bank of chiller fans that face longways on to five racks of metal shelves varying between 65cm and 125cm wide and each 300cm high. The shelves are stacked by hand – no fork-lift trucks means one less thing to go wrong. It is here in the bitter cold that Fowler addresses the problems of heat: "If you look at the projections of what kind of effect the heat from climate change is going to have, I think we have 20 years before we are in big trouble – and that's modest. Some areas will be affected worse." That is why so many of the samples in front of us now are maize. "If we still have the same varieties of maize in 20 years, we are looking at a 25 per cent decrease in production," Fowler says. "The population is growing, so that would lead to a more than 25 per cent decrease per capita. That would be an absolute disaster – we would be watching children starve to death on our TVs again."

Some experts claim that the situation is even more urgent. "We don't have 20 years," says Pamela Anderson, who runs the International Potato Centre (Centro Internacional de la Papa) in Peru. "Developing and disseminating crop varieties takes 15 to 20 years. We now have an active breeding programme in place to develop heat- and drought-resistant potato varieties for the developing world. We are racing against climate change." Others see a more nuanced set of threats. Sackville Hamilton fears we might be "missing the big picture, pandering to the immediate fuss about climate change. I don't mean to downplay the significance of climate change, but [it] is just the latest in a never-ending string of challenges we face and have to adapt to." Similarly Tim Wheeler rejects a precise time frame for two reasons: "First, although using germ plasm from the world's seed banks as a basis for developing new crop varieties better adapted to

Below: the entrance runs directly down to a blast-resistant wall



'THESE VARIETIES TELL AN AMAZING STORY OF THE EVOLUTION OF CIVILISATIONS AND CULTURES. IT'S A CULTURAL RESOURCE, A BOTANICAL ARTWORK. IT'S IMPOSSIBLE TO TELL THE HISTORY OF HUMANITY WITHOUT IT'

climate change is important, it is only one element of building an agricultural sector that is more resilient to a changing climate," he says. "Second, there is no single time-frame where we can say that, beyond it, we are in trouble. This is because the impacts of human-induced climate change on the world's crops will vary from place to place and change over time. For example, in northern Europe we expect a moderate degree of climate change to be beneficial to most crops. However, farmers in many tropical regions will see negative impacts in the next two or three decades."

It is that impact on the world's poorest that most concerns Fowler. He moves on to a box deposited by the International Centre for Agricultural Research in the Dry Areas in Aleppo, Syria. It contains samples of *Lathyrus*. "It's a sweet pea," Fowler says. "You will find it as an ornamental plant, but in Ethiopia, Somalia, India and Bangladesh it is a food crop. It's incredibly hardy, the most drought-proof crop in Ethiopia, and still lives when everything else dies. Two years ago I was with a farmer in Ethiopia and there were fissures on his land that you could put your arm in, up to the elbow, and this plant was still flowering. It is pest-resistant, survives floods and has the highest protein content of any food legume. A very important crop for poor people."

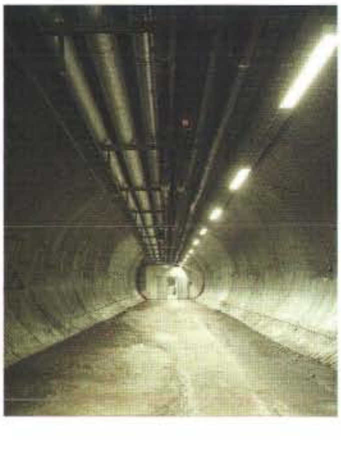
In many cases, Lathyrus may be the only crop that survives a particularly severe shortage of water, but therein lies another problem. "The plant contains a neurotoxin that becomes concentrated during a drought," Fowler reveals. "You can dissipate the toxin with water, but it's a drought - you don't have water." Those who use the legume as their primary food source "will be permanently paralysed from the legs down. Paralysis or starvation: it is a terrible choice, and it outrages me. These are the poorest people in the world." Yet the seeds that are held here, and those kept by the Syrian researchers attempting to develop low-toxin varieties, may hold the key to a future where hundreds of thousands of the world's poor do not have to make this "terrible choice".

If Fowler sounds like a crusader it's because he is - for him his work is a social obligation as much as a scientific endeavour. Born in Memphis, Tennessee, in the racially segregated American south, Fowler first developed his fascination with agriculture on his grandparents' farm. But his desire for social justice was forged the hard way, as a white middle-class high-school student who joined the often-violent Civil Rights marches of the 60s.

"I was there at Martin Luther King's last speech, the 'I've seen the promised land, I may not get there with you' one," Fowler recalls. "It was my first experience of real charisma. When he walked in the room - wow! You just felt it. Being involved in the Civil Rights movement, we were very visible. In a way, white southerners saw us as worse than the [black] enemy. We were traitors." Fowler received death threats for some years after. "One was particularly evocative," he says. "They said they were going to put me on the end of a firing squad and I would be the first to go. I just thought, 'Why would I be the first to go if they put me on the end?'"

Fowler refused to serve in Vietnam. "I was a conscientious objector, among the first people allowed to escape jail, and I did alternative service in a hospital," he says. His radicalism helped to shape his passion for agriculture. "They were both very strong tendencies," he says. "I look back at the Civil Rights struggle and think no one would question that now. But when I first started to encounter issues around agriculture at university, I realised there was other

Below: the "Svalbard tube" at the centre of the Global Seed Vault



Above: boxed-up seeds in cold storage. The temperature is -18°C

work I could do to help people, and things started to come together."

Formerly a professor and director of research at the Norwegian University of Life Sciences in Ås, Fowler has spent the last 30 years working in conservation and crop diversity. Consequently, he sees the vault as more than a resource that offers hope to the hungry; the seeds are also "an incredible library of life", he says. "These varieties tell an amazing story of the evolution of civilisations and cultures – the adaptation of crops over the last 12,000 years. It is also a cultural resource, a botanical artwork. The varieties are intertwined with different cultures. The reason we have all these varieties is because people saw the differences and valued the differences: they wanted corn and maize for making beer and for medicine and for bread. Some varieties were chosen simply because a particular person thought they were pretty. You wouldn't get crop diversity if you didn't have human diversity. It's impossible to tell the history of human beings without this – take this part away and you can't write the history."

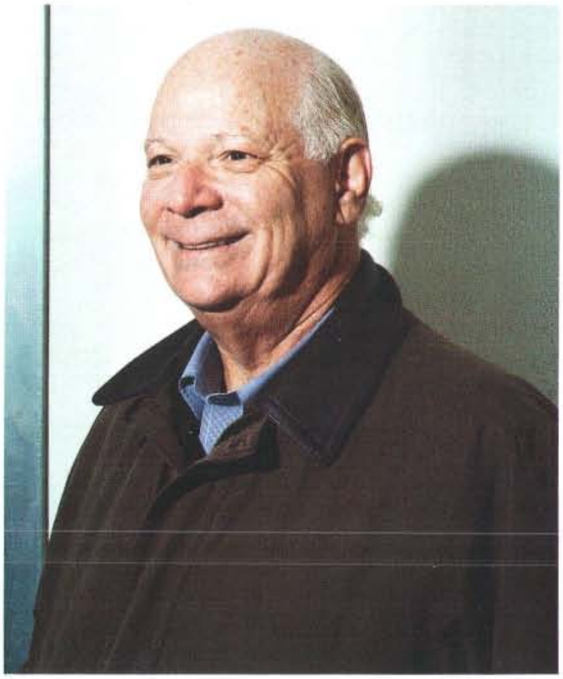
To illustrate his point, he highlights a variety of maize called podded corn. "You can find archeological remains of this corn from South America all the way up to Canada," he says. "It is associated with petroglyphs [rock etchings] of a hunchbacked flute player called Kokopelli. In Native American mythology he is a god of fertility and seducer of young girls. It was only after researchers discovered that the seeds originated in South America that it was realised the tribe had been sending medicine men to the far corners of their known world. The corn they took was used for medicinal and religious purposes. Kokopelli wasn't a hunchback; he was carrying a bag of corn. And we have that variety here in Svalbard."

Norwegian seafarers first visited Svalbard in the 12th century. Whaling and hunting were the main industries until the 19th century, when the discovery of coal led to the creation of two permanent townships: Longyearbyen, now home to 2,600 people, and Barentsburg, to the west, present population 500. Both towns were developed as mining centres, Longyearbyen by the Norwegians and Americans, Barentsburg by the Russians.

The mine shafts were dug horizontally into the sides of the mountains and there they remain, carved into the dark cliffs. The timber and iron structures are preserved by law, as are the wooden supports and pulleys that lead down to the old coal quays near the airport. It was the combination of Svalbard's isolation and low temperatures coupled with the mine shafts that first attracted Fowler's interest: the mines offered a prebuilt route into the permafrost. It was only after a miner pointed out that coal mines were prone to explosions, collapsing and flooding – and full of toxic gas – that he realised a new tunnel would have to be created. In 2004 he went to the Norwegian government ministry that controls Svalbard to request one.

Although the project would involve several agencies, it was

Below: US senator Benjamin Cardin, cochairman of COSCE



Fowler who secured support for the seed vault. "They didn't know much about seeds," he recalls of the Norwegian officials. "They listened quietly for 20 minutes. I said, 'This is one of the most valuable natural resources on Earth. The foundation of agriculture.' They said, 'And you say that Svalbard is the best place in the world to do it?' 'Yes,' I answered, 'it is.' They thought for a moment. 'Then how can we say no?'"

Fowler very nearly didn't see his project come to fruition: in 2004, when plans for the vault were advancing, he nearly died in a cycling accident near Oslo. Then, after already overcoming cancer twice (he had melanoma in 1972 and was told that he wouldn't survive more than six months, and had seminoma in 1982), he was diagnosed with basal cell carcinoma last year. "I had a bad form of a good cancer this time," he says calmly. "I was committed to my work beforehand, but even more so afterwards - you become aware of your mortality, of time."

And it is just that - time - that Fowler has bought the world. The vault is virtually indestructible beneath the permafrost - even if the power were to fail, the collection would remain cold enough to avoid deterioration. And, at 130 metres above sea level, the complex is secure from flooding even if the direst predictions of polar-melt come true. Seeds can survive for hundreds, in some cases potentially thousands, of years without germinating or losing their capability for life. Fowler was recently confirmed as executive director for another five years and, with the ongoing commitment of the Norwegian government, he sees Svalbard's future as assured for generations. "There is no reason to believe that the tunnel and vault rooms will not be there 1,000 or 10,000 years from now," he observes. "As structures go, this one could easily outlast the pyramids. And we have established a trust fund, invested conservatively, that will generate sufficient income to finance operations in perpetuity. The annual operating expenses are very modest, and thus [the finances are] actually quite small and easily manageable." Depositors, like Sackville Hamilton, agree: "I cannot conceive of a more secure system," he says. "The risks of losing this critically important diversity are now infinitesimally small."

At the ceremony to hand over the US politicians' seeds, Fowler gives a speech in front of Tanabe's wild-rice sculpture. The speech is shorter than he intended, as it becomes clear that the visitors' chinos and earmuffs will not stave off the cold, and even their crop-haired security men in tan raincoats ("We're here," one says, "to make sure there are no issues, *sir*") shuffle from foot to foot. So Fowler sticks to the basics, pointing out that we live in an interconnected world and, if we are to survive as it gets hotter, we must save our biodiversity and share our resources. To drive home his point, he offers the example that most of the highly productive rice grown in the US today originates from a variety developed in Turkey.

Afterwards, the assembled politicians seem a little awed by Fowler's presentation. "Americans enjoy their food and they enjoy the efficiency of agriculture today," senator Cardin admits. "But I don't think they understand the importance of diversity or that US farmers benefit from an insect-resistant seed developed in Turkey. We just take it for granted that food will be on our table. And the truth is that we cannot do that."

For Cary Fowler, it's another small step towards a bigger target. After marching with Martin Luther King, refusing to serve in Vietnam, campaigning for the poorest of the poor and surviving cancer three times, maybe saving the world's food resources isn't that big a stretch for him.

Michael Hodges is a writer and the author of AK47: The Story of The People's Gun

SEED VAULT ESSENTIALS

Svalbard has space for millions of plant specimens. But what are the key seeds we have to preserve?

Pamela Anderson: "The potato - it's the third most important crop in our global food-security system. Potatoes produce more nutritious food per unit area and water than any other staple crop."

Ruaraidh Sackville Hamilton: "I can't name one 'must have' species. All crops face the same issues. We need crop diversity for the traits to respond to climate change."

David Ellis: "Grasses (wheat, oats, barley, etc) and legumes (beans, peas, etc) have to top the list. Wild crop relatives are vulnerable to loss."

Left: Longyearbyen, one of the world's most northerly towns

The story ABOUT the movie BASED ON the book ABOUT Facebook

Sex! Hackers! Embellishment! How Hollywood turned a dorm-room start-up into a big-screen epic

By SCOTT BROWN
Illustrations: MARTIN ANSIN

MARK:
The site's live.
EDUARDO:
You know what? Let's go get a drink and celebrate.
[Pause]
Mark?
[Beat]
Are you praying?

MARK ZUCKERBERG IS MANY THINGS, not least a student of the classics. He reads Latin and ancient Greek, and his motto is said to be *Forsan et haec olim meminisse iuvabit*, or, loosely translated, "Maybe one day we'll look back on all this shit and laugh." Lately, though, he's probably meditating on another Latin phrase: *annus horribilis*. Because it's been one lousy year for the 26-year-old CEO, despite (and as a result of) the success of his dormitory-born company, Facebook, the most trafficked social-networking site on Earth. His media appearances have been called Nixonian, his hoodie choices have been savagely critiqued. His occasionally Orwellian quotes have been obsessively parsed. He's even been stalked by a Gawker paparazzo.

HARVARD
The Social Network
Written by
Aaron Sorkin

He might as well get used to it. When the movie based on his college exploits and Silicon Valley conquests hits screens this autumn, he'll become the first tech nerd to be granted Hollywood celebrity. But then, that's what happens when Tinseltown turns your life into film, your callow college years into fable and your billion-dollar company into a metaphor for American ambition and the inherent loneliness that lurks just beneath its dark-blue interface.

COMPUTER GUYS HAVE NEVER HAD A THIS-IS-OUR-MOMENT MOVIE THAT MAKES A SPLASHY MYTH OUT OF QUOTIDIAN REALITY – WHERE EVERYONE LOOKS SEXY-TORMENTED INTO THE BARGAIN

On October 15, with much fanfare and an eye on the Oscars, Sony Pictures is releasing *The Social Network*, its liberally dramatised, completely unauthorised and (its makers hasten to add) thoroughly researched Facebook-origin story. In this telling, Zuckerberg (played by 27-year-old Jesse Eisenberg) is no mere code monkey with a fondness for dead languages and flip-flops. He's a tragic archetype right out of Sinclair Lewis: the driven, wounded trickster-genius accused of stealing a million-dollar idea and throwing his friends under the bus, all in an attempt to summit the American dream. The filmmakers – Hollywood A-listers, all – can't be accused of thinking small. Justin Timberlake, who plays Mephistophelean Napster cofounder and Facebook partner, Sean Parker, calls the story arc "very Greek". Screenwriter Aaron Sorkin, creator of *The West Wing* and *A Few Good Men*, compares his version of Zuckerberg to Shakespeare's *Richard III*, saying of his protagonist, "Give him a hunchback and a club foot and you're pretty close." As for the film's acclaimed director, David Fincher, he jokes that he's made "the *Citizen Kane* of John Hughes movies".

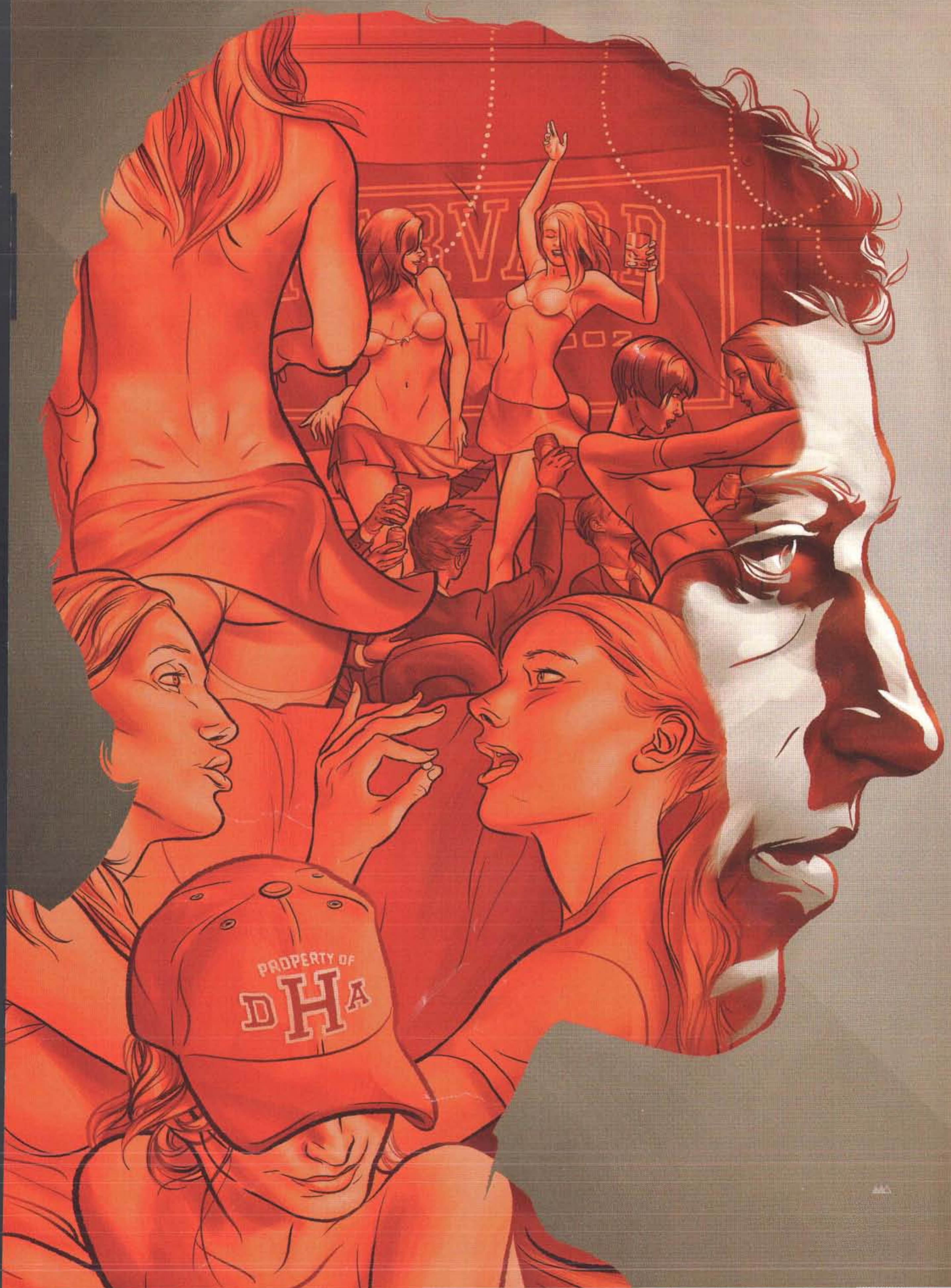
The *Fight Club* auteur may jest, but his Kane comparison isn't far off. As with William Randolph Hearst – Orson Welles' inspiration – Zuckerberg is the most recognised figure in his era's new media, and Facebook is as vital to mainstream culture as Hearst's publishing empire once was. As with Hearst, there's a tang of the ruthless and untoward about Zuckerberg and, as with Hearst, he has a talent for pissing people off. And it doesn't hurt that he's an absurdly young, grotesquely wealthy Harvard dropout. That's why Silicon Valley's first true – or rather "truthful", in Fincher's distinction – *zeitgeist* film isn't *Linux: Revenge of the Fallen*. (The news of a possible Google flick, no doubt inspired by *The Social Network*, generated little heat, probably because the company's motto is "Don't be evil".) With Facebook, there's just enough moral ambiguity, blended with just enough brand recognition, to attract Hollywood's attention.

For Silicon Valley, *The Social Network* ends decades of celluloid neglect. Oh sure, moviemakers love hackers, the same way they love Magical Black Men and Rapping Grannies. Fictional techheads always come in handy whenever the hero needs to pop open a locked door or drain a bank account; they roll their eyes at n00bs and proudly display Boba Fett figurines on their desks. But silicon minstrelsy doesn't confer much respect: until *The Social Network*, the computer business has been denied a mainstream biopic or a resonating social drama. Hackers have *Hackers* and *WarGames* and *Sneakers*, but they've never had their very own *Wall Street*: an empurpled, self-important, this-is-our-moment movie that makes splashy myth out of quotidian reality – where everybody looks sexy-tormented into the bargain.

Ironically, for all the prerelease rumblings about a Facebook movie, Facebook as we know it today barely makes an appearance in *The Social Network*. "From a plot standpoint, you could've told the same story about the invention of a really good toaster," Sorkin says. "The fact that it's Facebook just makes it ironic – that the world's most successful social-networking device was the work of a socially awkward guy."

For the studio marketers, Facebook's popularity and visibility are presumably helpful. But for the filmmakers, Zuckerberg was the draw. As with Facebook itself, the unreadable public Zuck is a fascinatingly content-free platform, a cipher that avid minds can't help but fill with their own interests and obsessions. "I'm not gunning for Mark in any way," Sorkin says. "I'm not blind to his jerky qualities. I wrote all about them. But if anything, I'm more apt to identify with him... We all get called losers." Fincher, whose *oeuvre* (*Se7en*, *Zodiac*, *The Curious Case of Benjamin Button*) hardly feels compatible with the story of a tech start-up, is similarly taken with Zuckerberg – though he seems to admire the guy's stones more than his vulnerabilities. "I know what it is to want to do it your own way. I sort of know what that anger is. I have nothing but respect for him. I look at him and go, 'You did it. You fuckin' did it.'" But which Zuckerberg are these guys addressing, exactly? The poker-faced Valley whizz-kid? Or their own creation – Citizen Zuck? Soon, it may not really matter. If early buzz on the film is any indication of potential impact, *The Social Network* could be widely regarded as the definitive portrait of Zuckerberg. Myth is about to overwrite reality, whether the man in question "accepts" or "ignores" it.

The Social Network purports to offer a "truthful" take on Zuckerberg and Facebook's formative college experiences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BEN MEZRICH HAD A PROBLEM. "WHAT WILL THE NEXT bestselling Ben Mezrich book be about?" he wondered, lazing in his palatial Back Bay lair. Suddenly, the phone rang. It was destiny calling. "Hello," said a mysterious voice. "I'm the wronged, forgotten cofounder of Facebook, and I want to tell my story."

OK, so that's not exactly how the seeds of what would become *The Social Network* took root in the winter of 2008. But sometimes, telling a story with literal precision isn't the point: the factual record can take you so far, and then deeper truths must be allowed to suffuse the interstices. This seems to be the journalistic philosophy of Mezrich, an author of thrillers turned chronicler of real-life nerd adventures. Mezrich is most famous for *Bringing Down the House*, a dramatic tale of wily MIT maths freaks using advanced card-counting techniques to milk Las Vegas blackjack tables for millions. The story was optioned and eventually used as the basis for the movie *21*. Mezrich admitted he'd enhanced his account with composite characters and reimagined scenes. Despite these concessions, he also maintains the book is a "99.9 per cent true story".

Since *Bringing Down the House*, Mezrich's potboiler writing style and nonchalant attitude toward verisimilitude have earned him a slew of critics, Facebook now among them. The company publicly derided him as the Jackie Collins of Silicon Valley when Mezrich published *The Accidental Billionaires: The Founding of Facebook. A Tale of Sex, Money, Genius, and Betrayal* – the germ cell for *The Social Network*. As with *Bringing Down the House*, many of its individual facts are hotly contested. But one thing he's sure of, according to Mezrich: "Facebook is scared of the movie, scared of the story I told."

That story originated with Eduardo Saverin, who contacted Mezrich in 2008 through a friend. He said he was the cofounder of Facebook, its former CFO and the original investor. He claimed he'd been betrayed by Zuckerberg, screwed out of millions of dollars by a guy he thought was his friend – a fellow nerd who'd shared his (rather Earthbound) dreams of being popular, gaining entry to selective social clubs, and, of course, getting laid. "Eduardo was an angry kid at the time," Mezrich says. "He'd been expunged from the story of Facebook. I built a relationship with him over a couple of months." Saverin was already suing Zuckerberg,

MARK:
A guy who makes a really nice chair doesn't owe money to everyone who's ever built a chair

Justin Timberlake and Jesse Eisenberg as contrasting former Facebook partners Sean Parker and Mark Zuckerberg

but he also seemed to want his side of the story told, and Mezrich wanted very much to tell it. He invited Saverin and his friends to the Vegas premiere of *21*, hoping the full red-carpet treatment would keep him talking. It did – to a point. "I was close to a draft when Eduardo freaked out," Mezrich says. "Mark found out he was talking to me and made it part of the settlement that Eduardo couldn't speak to me again." (Saverin wound up with a reported five per cent of the company, worth roughly $600 million. He didn't respond to an interview request.)

Around the same time, twin brothers and Harvard alums Tyler and Cameron Winklevoss, along with their college friend and former business partner Divya Narendra, were also in the process of suing Zuckerberg for intellectual property theft. The twins had hired Zuckerberg in his second year at Harvard to code a social-networking site; he'd agreed to do it but never finished the work and launched his own competing site – then called Thefacebook – a few months later. Court records brought to light a personal blog Zuckerberg had kept at Harvard. In one beery entry, he called a girl who dumped him a "bitch" – and then carried out a devilish hack, inviting readers to follow along. The result was the Facemash, a makeshift hot-or-not game fuelled by photos plundered from university databases. The irresistibly cruel little timewaster went viral across Harvard's networks, making Zuckerberg a campus celebrity. Even as Mezrich sorted through this pulpy trove of material, Facebook was hitting a bad patch. The 23-year-old Zuckerberg, previously renowned as a wunderkind, came across as defensive and chilly in a *60 Minutes* appearance. (One blogger described him as "genetically unable to smile".) Did the Valley's golden boy have a dark side? Had he been a bit of a scamp back in his school days? And was he still? Suddenly, Mezrich had a real character on his hands – and a potential movie in the offing: "I was thinking, 'This is *Superbad* in the midst of a multibillion-dollar company.'" He didn't wait to write the book: he dashed off a 28-page treatment (immediately leaked to Gawker) and sent it to Hollywood, where, he says, "Sorkin saw it and went bananas".

Suffice it to say, Sorkin didn't see the movie as *Superbad*. He saw a chamber epic, recounted *Rashomon*-like, with three different perspectives from the film's main characters: Zuckerberg, Saverin and the Winklevosses. "What drew me to it were the themes that were as old as storytelling itself," he says. "Friendship, jealousy, loyalty, power, love, betrayal. The kind of things that Aeschylus would write about – but the invention at the centre of it couldn't be more contemporary." With Sorkin aboard, Sony sealed the deal on the property, and Mezrich and Sorkin proceeded to work in parallel, completing the book and screenplay at roughly the same time – highly unorthodox for Hollywood, but then, so was making a movie about a website.

"Sorkin came to Boston and was eager to get going on it," Mezrich says. "We sat in a room in the Four Seasons, and I just handed him chapters. I had all this incredible documentation that had been given to me by... well, I don't want to say who. You can figure it out." Sorkin is even cagier about the research he conducted (citing court-imposed gag orders and ongoing lawsuits involving his sources), though both he and Oscar-magnet producer Scott Rudin stress that a vast amount of shoe-leather reporting, independent of Mezrich's material, went into the script. (Mezrich and Sorkin did tour a couple of Harvard's "final clubs" together to get a feel for the invitation-only men's societies, which allegedly obsessed Saverin and Zuckerberg and may have inspired the early Facebook's "exclusive" ethos.) The movie and book versions converge on several points (the primacy of sex, partying and social acceptance), but there are key differences: Mezrich implicitly takes Saverin's side, whereas Sorkin's script unfolds as a series of legal depositions, thus highlighting the tale's ambiguities. (He also axed Mezrich's disputed account of Zuckerberg eating koala meat on a yacht and a digression about a Zuck assignation with a Victoria's Secret model.)

Rudin, meanwhile, assiduously solicited Facebook's involvement, even slipping the company a copy of the script and showing senior officials a cut of the movie. Facebook's official spokesperson inadvertently contributed a line to the movie: critiquing the script, he said, "Every creation myth needs a devil." (Sorkin loved the line and

EDUARDO SAVERIN SAID HE WAS THE COFOUNDER AND FORMER CFO OF FACEBOOK. HE SAID HE'D BEEN BETRAYED. SCREWED OUT OF MILLIONS BY A GUY HE THOUGHT WAS HIS FRIEND put it in.) Nevertheless, Zuckerberg and Facebook elected not to co-operate with the movie. (Or this story. The company provided only this statement: "The story presented in *The Social Network* doesn't match reality. It's a portrayal designed to lure people into cinemas rather than tell an accurate story.")

But by that time – in fact, from the moment its existence became public in August 2008 – "the Facebook movie" had a more fearsome enemy than Facebook: the internet. The doubters were merciless, blog and troll alike. They smelled classic Hollywood fadphreaking – or maybe a fiendish corporate Face-plot to invade the multiplex. Such brutal, know-nothing speculation might be enough to put a sensitive screenwriter off the internet entirely; and indeed, web aversion was why the project leaked in the first place. You'll have to forgive Sorkin: he'd never used Facebook before. He created a group page to conduct research without realising that the page was viewable by anyone on the web. "I'd heard of Facebook the way I'd heard of a carburettor," he admits. "I really didn't know what it was." He wised up when Gawker and like-minded snark factories instantly began cracking *A Few Good Pokes* jokes. (Sorkin had his defenders, as well: those who pointed out how he makes smart people look sexy and technical subjects feel accessible, even thrilling.) But the carping quieted when Fincher, fresh off an Oscar nomination for *Benjamin Button*, signed on. Contempt turned into curiosity. Sorkin, Fincher and Facebook? Was there something we weren't seeing?

"I didn't want to do *Revenge of the Nerds*," Fincher says. "I don't believe in this Mountain Dew-swilling, people-who-haven't-bathed, staring-at-phosphorescent-screens-with-luminescent-white-skin hacker stereotype. These are people who make stuff. I feel like they're kindred spirits." Still, he acknowledges that these kindred spirits are whole-cloth movie characters, not carbon facsimiles of actual persons. Fincher encouraged his actors to break free of their real-life counterparts. It's how he'd approached casting, after all. "There were a lot of people – more than one, more than two – who said, 'Justin Timberlake? Sean Parker is more like Art Garfunkel,'" he says. "But I need Mark to look across a restaurant table at Sean and say, 'That's what it looks like to have arrived.'" Timberlake, who once met Parker briefly (but before he was actually cast in the film, he says), sees the big-screen version of Parker in purely cinematic terms: his character's job is to "send the movie into Gordon Gekko land," a place where the temptations of a new *Wall Street* beckon.

The spirit of invention was in full force when it came to building the 'Berg himself. "I watched all the videos I could find online," says Jesse Eisenberg, who was asked not to meet Zuckerberg. "They proved not that helpful. Mark never gives grand speeches, not the way Aaron Sorkin crafts speeches. The challenge was reconciling the tabula rasa of Mark, his passivity, with these more grandiose, more aggressive monologues." Running up against the impregnable wall of Zuckerberg's clammy media appearances, Eisenberg turned to studying his own highly intelligent, socially awkward friends and relatives (including one cousin who actually works at Facebook). He also read books on Asperger's syndrome, though he's quick to admit he doesn't know if Zuckerberg actually has it. At least it was a starting point: a way to explain the character's emotional terseness and androidal reactions to humour and hugs, alongside Sorkin's sudden bursts of perfectly articulated oratory.

And so, just two years after Mezrich first put fingers to keyboard, teasers and trailers for *The Social Network* began to appear. And, to everyone's surprise, they were... kind of awesome. One moody preview features the song "Creep" by Radiohead, covered by a Belgian girls' choir, and knits footage of mundane Facebook usage together with tense, *Fight Club*-ish images of splintering male friendships and nightmarish bacchanals: women writhe, champagne spurts, nerds code. Darkly.

The web gasped, genuflected a bit. And then bestowed upon the trailer its highest honour: a gazillion parodies. In one, the real-life Zuckerberg's famously sweaty meltdown at the D8 tech conference (where probing questions about privacy had him shedding his trademark hoodie) has been underscored with the "Creep" soundtrack. The effect is uncanny: fact and fiction blend seamlessly. And creepily. This, one senses, is Facebook's ultimate nightmare.

A LITTLE INFAMY NEVER HURT ANY CORPORATE OVERLORD. FACEBOOK MIGHT COUNT ITSELF LUCKY. *THE SOCIAL NETWORK* MORE OR LESS DECLARES ZUCKERBERG AN UNALLOYED (IF SLIGHTLY EVIL) GENIUS

ERICA takes **MARK's** hand and looks at him tenderly...
ERICA:
Listen to me now. You're going to be a very successful computer person. But you're going to go through life thinking that girls don't like you because you're a nerd. And I want you to know, from the bottom of my heart, that that won't be true. It'll be because you're an asshole.

The Social Network arrives in the midst of an image crisis for Facebook that extends far beyond the silver screen. The company's aggressive and often unilateralist push towards user transparency – publishing friend lists, broadcasting user activity on and off the site via "instant personalisation" – has helped land it somewhere below the US Internal Revenue Service in user satisfaction, according to the American Customer Satisfaction Index. In the teeth of this, Zuckerberg has been deployed as figurehead and chief spokesgeek. If Hollywood then paints him as a Kane-like robber baron with a serious humanity deficiency, well, that's bad, right?

WHO'S WHO IN *THE SOCIAL NETWORK*

Name: Mark Zuckerberg
Status: Awkward curly-haired Facebook CEO has built a fortune around being a baby-faced nerd

Played by: Jesse Eisenberg
Status: Awkward, curly-haired indie film-star has built a career around playing baby-faced nerds

Name: Sean Parker
Status: Former Facebook president and Napster cofounder is best remembered for ripping music off the internet

Played by: Justin Timberlake
Status: Pop singer is best remembered for ripping Janet Jackson's bra off at the Super Bowl

Name: Eduardo Saverin
Status: Zuck's former best friend becomes Facebook's CFO, is then shocked when he's asked to step down for Sean Parker

Played by: Andrew Garfield
Status: British thespian plays Saverin; shocked when asked to step in for Tobey Maguire in the next *Spider-Man*

Name: Tyler and Cameron Winklevoss
Status: Chiselled twin brothers manage to litigate their way to a fortune ($65 million, but who's counting?)

Played by: Armie Hammer
Status: Chiselled actor is heir to a fortune (related to oil tycoon Armand Hammer, but who cares?)

Not necessarily. A little infamy never hurt any US corporate overlord – just ask Donald Trump. Facebook might even count itself lucky. *The Social Network* makes no mention of the privacy controversy, the site's greatest PR liability. What's more, the movie more or less declares Zuckerberg an unalloyed (if slightly evil) genius. He's got some ripping speeches, too, and all the most quotable lines, all the best fuck-you moments. (And fuck-you moments, as we all know, are the riffs moviegoers repeat on the ride home – and then in their status updates.) Best of all, the movie steers clear of the real Zuckerberg's less, er, mythic qualities. Citizen Zuck is charismatic, restrained, often dryly, witheringly funny. The "real" Zuckerberg, on the other hand (according to *The Facebook Effect*, the corporate history he himself authorised), was often given to swinging a fencing foil in the faces of friends and associates, and quoting the movie *Troy*. "Now you know who you're fighting!" he'd declaim in his Achilles persona, often apropos of nothing. The movie doesn't go there: no foils, no *Troy*, no epic-dorkdom. On the advice of Sony's lawyers, Sorkin says he even obligingly cut a line referring to recently unearthed instant messages that may or may not cast new light on the Winklevosses' claims against Zuckerberg. And nobody in the movie brings up that insane-looking Facebook Illuminati symbol, which the flesh-and-blood Zuckerberg custom-stitched into the inside of his hoodie.

Citizen Zuck is, frankly, way cooler than all that. Real or un, Aspie or norm, it's all irrelevant: he's an American icon now, up there with Jay Gatsby and Elmer Gantry and George F Babbitt – and he might yet prove to be the best thing that's happened to Facebook in a long while. At the very least, he's given the man himself a much better movie to quote around the office, something a little more Greek than crummy old *Troy*. As a classics man, he ought to appreciate that. Maybe one day, he'll look back on this and laugh. *Forsan et haec olim meminisse iuvabit*, right? Right. But that's a big *forsan*.

Scott Brown is a regular contributor to WIRED *US*

SUPERCHARGED:

Elon Musk, Tesla Motors' CEO, with the forthcoming four-door, seven-seater electric Model S sedan

By JOSHUA DAVIS

Photography: ADRIAN GAUT

HOW ELON MUSK AND TESLA MOTORS MADE ELECTRIC CARS COOL

Elon Musk looks like a kid who just walked into a toy factory. The 39-year-old CEO of upstart car company Tesla Motors stands on the floor of the New United Motor Manufacturing plant and looks with awe from one giant piece of machinery to the next. The car factory, known as Nummi, is located in Fremont, California, but it's an industrial city unto itself. It encompasses 500,000 square metres and contains a plastics-moulding factory, two paint facilities, 2.4 kilometres of assembly lines and a 50-megawatt power plant. Since 1984, Toyota and General Motors had run Nummi together, producing as many as 450,000 cars a year here until it was shut in April. Now, in a remarkable turn of events, Musk owns the place.

He seems as surprised as anyone at this development. For years, the exuberantly ambitious entrepreneur wasn't even allowed to visit. Nummi's plant managers apparently frowned on the idea of a potential competitor touring the facility. Not that they had much to fear: in 2009, Tesla managed to produce only about 800 high-performance electric sports cars – a niche manufacturer in an industry that churns out millions of vehicles.

But Musk never intended to be a niche player. After making roughly $180 million as a cofounder of PayPal, he helped get Tesla off the ground in 2004 with an initial investment of $6.3 million. The start-up's audacious business plan had three steps. First, develop a high-end, high-performance sports car to prove that electric vehicles were both cool and feasible. Second, roll out a luxury sedan that would compete with high-end brands such as BMW and Mercedes. Third, produce hundreds of thousands of low-cost electric vehicles for the masses.

Musk has pulled off the first step. In 2008, Tesla released the Roadster, a two-seat sports car, and has since sold just over 1,300. By 2009, the US government agreed to lend the company $465 million from an alternative-vehicle fund to launch phase two: challenge the car industry head-on by mass-producing the Tesla Model S, a stylish four-door sedan powered by more than 7,000 lithium-ion batteries.

Just one problem: Musk didn't have a factory. Tesla was outsourcing most of the Roadster manufacturing, assembling the cars one by one in a garage behind its showroom in Menlo Park, California. (The building had once been a Chevrolet dealership.) Fabrication on a mass scale was impossible there. Musk needed a legitimate facility like Nummi, but the plant had recently been valued at nearly $1 billion – way beyond what a small start-up could afford.

But in March of this year, Nummi plant managers got an unexpected call. Akio Toyoda, president of Toyota, had given permission for Musk to conduct a clandestine tour. Toyoda wanted to see whether Musk was interested in buying the factory and needed to keep it quiet to prevent media attention from scuttling a deal. At the time, the car industry was in the process of retrenching after the economic meltdown of 2008. GM had already pulled out of the plant after declaring bankruptcy in 2009, and Toyota planned to stop producing in less than a month. There weren't too many people interested in buying an 81-hectare white elephant of a car factory, so Toyoda opened the door for Musk.

On his first visit to Nummi, Musk donned a hard hat, a blue jacket and plastic safety goggles, and acted as inconspicuously as possible in the hope of not being recognised. As a Nummi plant manager led him discreetly through the factory, he gawked at the scale of the place and tried to suppress his excitement. Hundreds of Toyota Corollas and Tacoma trucks rolled down assembly lines. Thousands of people buzzed about. It was everything he had dreamed of for Tesla. He offered what he had budgeted for a more modest factory: $42 million. A month later, to his astonishment, the offer was accepted.

Now, on his second visit to the plant – his first as its owner – Musk is trying to get his bearings. Just five weeks earlier, Tesla had gone public, netting $238 million and making it the first American car company to complete an initial public offering since Ford in 1956. As a result, the company has access to more than $700 million, a significant portion of which will go toward retrofitting the facility. It's a daunting task. Musk walks past row after row of motionless robotic drills. A multi-tonne crane stands idle beside a 20-metre-tall steel press. The ceiling soars high overhead, making even the press look somehow small. For a moment, Musk appears overwhelmed by what he's got himself into.

"Holy crap, this place is big," he says, but then he flashes a smile. "It's perfect."

In 2009, the US government agreed to lend Tesla $465 million to mass-produce the stylish, lithium-ion-powered Model S. Just one problem: Musk didn't have a factory

Just three years ago, Tesla Motors was in big trouble. The company's inaugural product, the $109,000 Tesla Roadster (£86,950 in the UK), was due to begin production in September 2007, but an internal audit revealed that the cost to build the car had climbed to $140,000. It was a money-loser before a single unit had been delivered.

Musk was the lead investor but wasn't running the company then, and he was taken aback by the state of affairs. He'd been led to believe that manufacturing the car would cost $65,000 and decided to investigate. He visited the body-panel fabricator, Sotira, and discovered that the French facility didn't have the right tools to do the job. The car wasn't just too expensive – as things stood, it couldn't even be built.

At this point, Musk and other investors had sunk nearly $100 million into the company and didn't have a single car to show for it. Martin Eberhard, CEO at the time and one of Tesla's founders, was demoted and in a matter of months left the company. Michael Marks, an investor and former head of electronics maker Flextronics, stepped in as interim CEO.

Marks immediately drew up a list of roadblocks standing in the way of the car being built. The transmission didn't work, the air conditioning didn't work, the quality of the seats was unreliable – the list kept growing. The situation, Marks wrote in an email, was "a lot scarier and [more] pressing than I thought". Work on the Roadster was put on hold – the company, Musk says, was in a "near-fatal financial situation". He had boasted that Silicon Valley smarts could beat hidebound old Detroit at its own game. Now that wasn't looking so easy.

At the end of 2007, Musk decided to put another $20 million into Tesla. He wasn't ready to concede defeat, because for him there was more at stake than just creating a viable company. The combustion engine had made the world dependent on oil, resulting in climate change, massive transfers of wealth to oil-producing countries and heightened geopolitical tensions. Musk believed that the auto industry had too much financial and psychic investment in the engine to admit that the 19th-century technology had outlived its usefulness. Tesla, however, could jump-start the electric-car era and help solve the problem.

The impact of switching to electrics would be transformative, Musk believed. With the combustion engine, we've been largely stuck with oil to produce fuel for transportation. Electricity, on the other hand, can be produced in many ways – by a coal-powered plant, a nuclear reactor, a hydroelectric generator, a wind farm or a solar array. In a world dominated by electric cars, all these power-producing technologies would be spurred to compete, encouraging innovation. What's more, an electric engine is inherently more efficient than a combustion engine: one gallon of petrol could be used to generate enough electricity to power an electric vehicle for hundreds of miles.

Despite the manufacturing challenges, Tesla's engineers had successfully designed a durable and powerful battery pack using lithium-ion laptop cells. It was no easy task. Lithium-ion batteries can explode if overheated, so the team came up with an innovative cooling system that circulates water and antifreeze in sealed tubes throughout the battery array. They installed sensors that would disconnect the battery within milliseconds in the event of a crash or if smoke, humidity or water entered the pack. At the same time, the batteries provided 200 kilowatts of juice – enough to let the 288-horsepower motor rocket the Roadster from zero to 60mph in less than four seconds.

The 32.5cm rotor at the core of the Model S, the electric car Tesla aims to begin producing in 2012

The auto industry began to take notice of the little start-up with the big ideas. In January 2007, GM unveiled a prototype electric vehicle. In a *Newsweek* interview, Bob Lutz, then GM's vice chair, said, "If some Silicon Valley start-up can solve this equation, no one's going to tell me any more it's unfeasible." That year, Daimler unveiled plans to develop an electric version of its Smart car. The major carmakers were moving into electrics so fast that Tesla risked being left behind by the wave it had generated.

Musk tried to accelerate the roll-out of the Roadster by hiring Ze'ev Drori – a no-nonsense ex-Israeli paratrooper and microchip executive – as CEO. While Drori focused on solving the Roadster's problems, Musk started to think about ways to bring in more income. One option was to try to ride the electric wave by selling battery packs to the larger manufacturers. The income could keep Tesla alive long enough eventually to compete head-to-head.

Still, Musk tried. In September 2007, he flew to Stuttgart, Germany, and met with a group of Daimler executives, who listened sceptically as Musk told them how great his technology was. They weren't sold. But two months later Musk got an email from Herbert Kohler, Daimler's head of advanced engineering, saying he and other Daimler execs would be in California in six weeks and would be willing to look at Tesla's technology.

It was all Musk needed. He called JB Straubel, Tesla's CTO.

"We need to make an electric Smart car in six weeks," Musk said to Straubel. "Can you do it?"

Straubel pointed out it would mean he'd have to pull engineers off the Roadster at a time when they were desperately trying to solve production problems. It was a tough call, but Musk believed that if they could prove themselves to Daimler, they could win a valuable contract. It would validate Tesla in the eyes of the world. They had to try.

But where would Straubel get a regular, petrol-powered Smart car to retrofit? At the time, Daimler didn't sell Smarts in the US.

Discovering the cars were sold in Mexico, he located a dealership in Tijuana. He needed someone to fetch a car. A Tesla engineer suggested a friend who was fluent in Spanish. He agreed to head south. Straubel spoke to the finance department. "I need $20,000 in cash right now," he said. "We're sending someone to Tijuana to buy a Smart car."

Three days later, the engineer's friend showed up at Tesla headquarters with a brand-new Smart car. Straubel and his team removed the 83-horsepower petrol engine and set to work building a custom battery pack that would fit in the tiny car's engine compartment. Next, they refashioned a Roadster motor to power it. When they got too tired, they napped under a staircase, but the pounding of feet overhead made it hard to sleep for long.

Finally, at one o'clock in the morning, five-and-a-half weeks after setting to work, the re-engineered Smart was fully assembled. Straubel got in the driver's seat and switched on the power. He goosed the accelerator and rocketed out of the garage and into the car park. When he floored it, the front wheels lifted off the ground and the back tyres left marks on the asphalt.

Straubel called Musk and told him the car was ready for the Germans.

* * *

The Daimler executives sat down in Tesla's conference room mid-morning on January 16 2008. Musk hosted a PowerPoint presentation explaining the advantages of the Roadster's technology. Kohler wasn't impressed. He wasn't here to talk about a limited-run show car. He wanted to know if Tesla could mass-produce battery packs for the Smart. His frosty demeanour indicated that, in his opinion, it didn't seem likely.

"We've got something to show you," Musk said, asking the Daimler execs to follow him.

Kohler spotted the shiny new Smart sitting in the garage and didn't smile. Musk had got a Smart into the US. Big deal.

"It's electric," Musk said.

"What do you mean?" Kohler asked.

"We put in a Tesla battery and motor."

Kohler examined the car. Straubel hadn't altered its shape or interior, so it was impossible to tell it had been modified. Kohler got behind the wheel and Musk hopped in the passenger seat. When the German stepped on the accelerator, the car bolted out of the garage and disappeared. Straubel waited nervously with the other Daimler execs. After 15 minutes, the Smart tore back into the garage. Straubel noticed that the taciturn Kohler was trying not to smile.

"Let's explore a partnership," Kohler said to Musk.

Over the course of 2008, Tesla solved the production problems on the Roadster and, one by one, the cars started to hit the streets. The reviews were glowing. The US *Car and Driver* called it a "revelation" and *Motor Trend* gushed: "The Roadster is a cool automobile technically, a cooler automobile to drive and a historic game-changer in our perception of battery-electric vehicles." Musk accumulated hundreds of orders for the $109,000 car. It looked as if the company might survive after all.

Musk, however, wasn't interested in just surviving. Though he said the company could reach profitability if it focused just on the Roadster and the battery-pack business, he didn't rein in his ambition. The point, after all, had never been to supply fast cars to rich people. The point was to transition the world to electric transportation. He didn't think small. His other main business, a rocket company called SpaceX, aimed to replace the Space Shuttle and take people to Mars. With Tesla, the Roadster was simply a proof of concept that set Musk up for the next step in his business plan: the Model S.

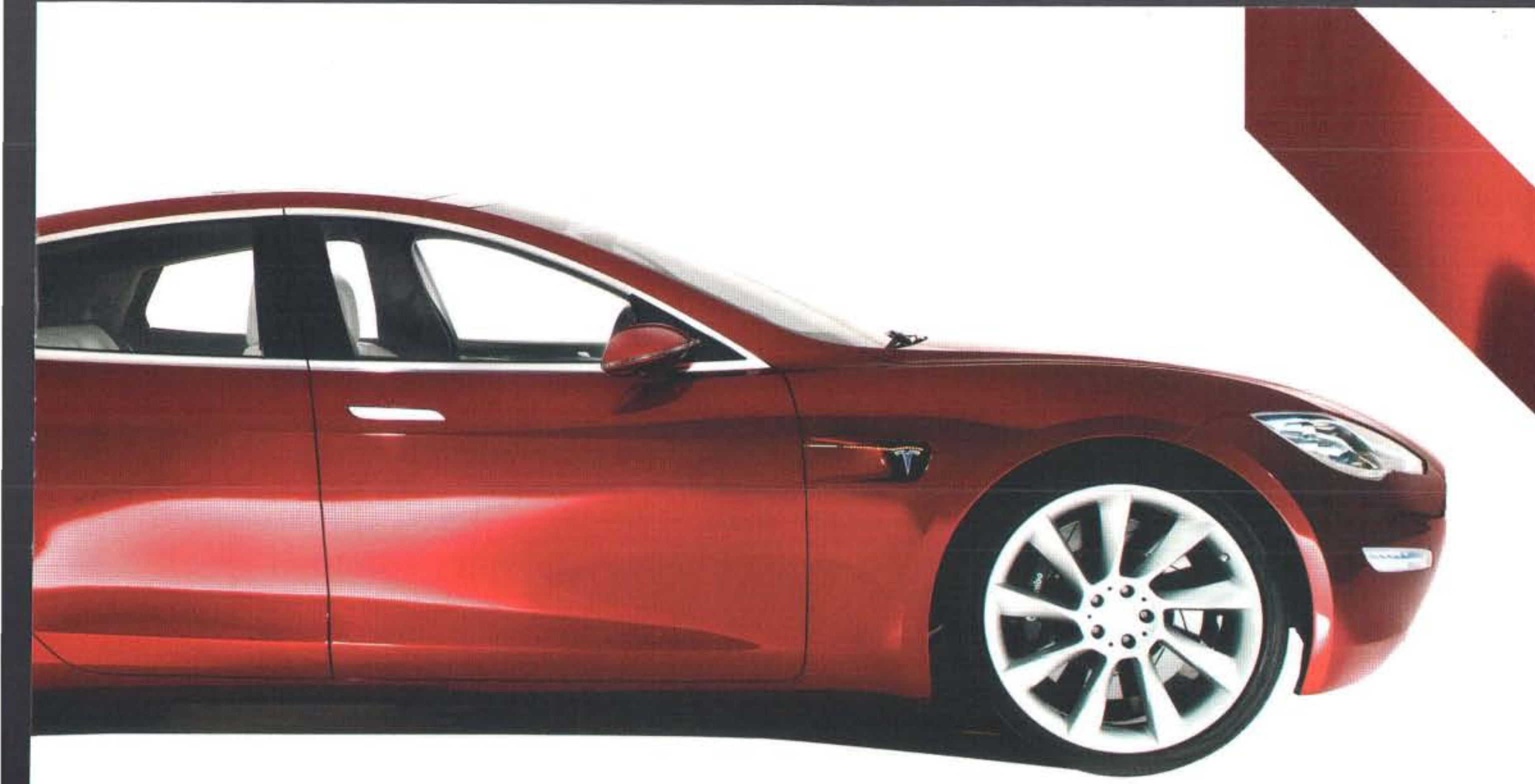
Musk hadn't become wary of innovation. In the summer of 2008 he got bolder: to rev up the sedan effort, he hired Mazda's lead North American designer, Franz von Holzhausen, and told him he wanted a four-door, seven-seater car.

"That's an SUV, not a sedan," von Holzhausen responded.

Musk countered that von Holzhausen had a rare opportunity to design something new. They were going to build their own chassis from the ground up. Since this new vehicle didn't have to accommodate exhaust pipes, thermal shielding to protect against engine heat, or bulky catalytic converters, there would be a lot of extra space. That meant it was theoretically possible to put in a third row of seats. Musk didn't just want to build a functioning electric sedan – he wanted to redefine what a sedan could be.

Given the response to the Roadster, Musk was confident that he could raise another $100 million that summer to send the Model S into production. Goldman Sachs was arranging the financing and sounded bullish. Then the subprime mortgage crisis began to spiral out of control. Major banks were on the verge of collapse. The last thing investors wanted to do was put money into a start-up car company. By October, Goldman had made little progress, and Musk told them to give up.

Tesla's Model S sedan: up to 480km per charge; zero exhaust emissions



Musk's point was to transition the world to electric transport. The Roadster was simply a proof of concept that set Tesla up for the next step in the business plan: the Model S

hroughout the autumn of 2008, Musk watched Tesla's bank balance drop by the week. His team had been able to bring down the cost of producing the Roadster to approximately $95,000 by renegotiating supplier contracts and redesigning parts to be simpler. Still, Tesla had pre-sold the car in 2007 to hundreds of buyers at a discount price of $92,000. Costs were continuing to drop – they could make it to profitability if they didn't go out of business first – but by the end of the year, Tesla had less than $500,000 in the bank. They were in danger of not making payroll. Bloggers mounted a Tesla deathwatch.

Musk was down to the last $20 million or so of his personal fortune. Tesla and SpaceX had consumed the rest. If he held on to the $20 million, he could walk away and still be rich. He was 37 years old – he had plenty of time to try something less risky.

He called his younger brother, Kimbal, who had invested more modestly in Tesla, and told him that the company needed another cash infusion. The two had made millions together in 1999 when they sold Zip2, an online media-services company, to Compaq. Kimbal, who lives in Boulder, Colorado, was about to order a coffee at Starbucks when his phone rang.

"You really think it's rational to put more money in?" Kimbal asked, implying that maybe it was time to move on.

"We're so close," Musk said. Kimbal could hear the stress in his brother's voice. Musk's marriage to the novelist Justine Musk had just fallen apart, and one of his SpaceX rockets had recently failed to reach orbit in a botched launch. Still, Musk wanted to take on yet more risk.

"Daimler's almost there," he said. "The Roadster's almost there. We can't quit now."

Musk knew what needed to happen: make the Roadster profitable and build battery packs for Daimler, then use that revenue to stay alive long enough to get loans from the government and launch the Model S. He was ready to put the last of his money in, but if any one of those things didn't come through, it'd be over. It didn't matter. Musk was convinced he could pull it off. He had asked Drori to step down as CEO and took over the role himself. He was going all-in.

"Elon has huge steel balls," his ex-wife notes on her blog. "He truly does."

Kimbal found himself believing they could make it and agreed to put in more of his own money. Musk soon persuaded most of his other investors to pony up emergency funds, raising a total of $40 million. The company was going to have one last shot.

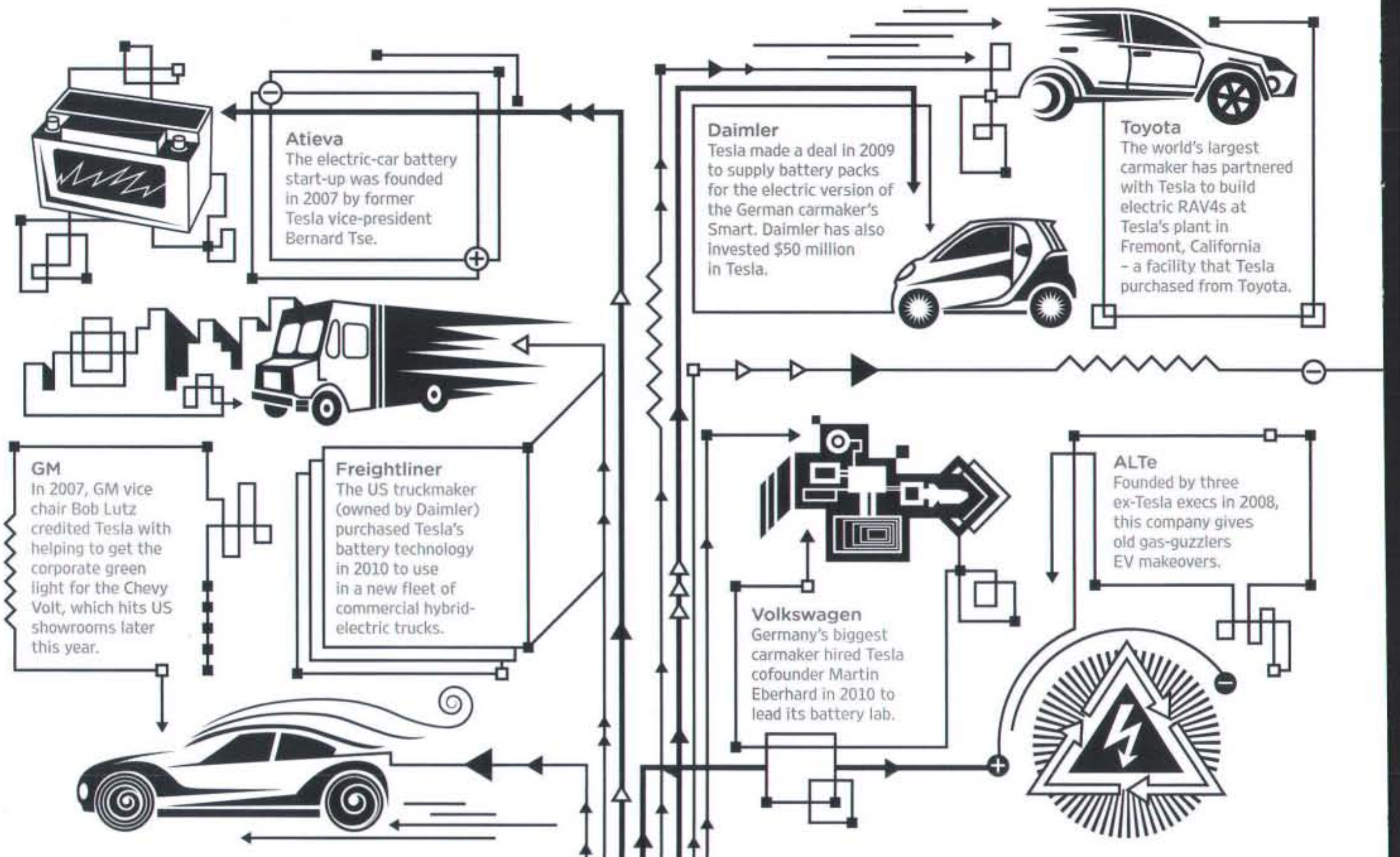
But underneath the bravado, Musk wondered if he'd have to start over with nothing. He got a taste of what that would be like when he found himself borrowing money from friends to pay living expenses. "At that point, every day was like eating glass and staring into the abyss of death," he says.

* * *

The emergency funds kept Tesla afloat, and things started to unfold as Musk had predicted. In January 2009, Daimler bought 1,000 battery packs for the Smart in a deal worth more than $40 million for Tesla. Then, in May, Daimler agreed to buy a nearly ten per cent stake in the company for $50 million, giving Tesla a valuation of more than $500 million. Importantly, a pioneer of the internal combustion engine was vouching for the tiny electric-car start-up.

Throughout the financial turmoil at the end of 2008, von Holzhausen had focused on designing the Model S. In March 2009, he'd finished a prototype. It was no ordinary sedan. The car had the sexy, sloping lines of a Porsche and the muscular stance of a BMW. The company unveiled it in front of hundreds of people at Musk's rocket factory near LA. When von Holzhausen

The Tesla Effect It may be a tiny start-up but Tesla Motors has energised the auto industry. Here's how it influenced carmakers and suppliers worldwide. *Allison Davis*



Atieva
The electric-car battery start-up was founded in 2007 by former Tesla vice-president Bernard Tse.

Daimler
Tesla made a deal in 2009 to supply battery packs for the electric version of the German carmaker's Smart. Daimler has also invested $50 million in Tesla.

Toyota
The world's largest carmaker has partnered with Tesla to build electric RAV4s at Tesla's plant in Fremont, California – a facility that Tesla purchased from Toyota.

GM
In 2007, GM vice chair Bob Lutz credited Tesla with helping to get the corporate green light for the Chevy Volt, which hits US showrooms later this year.

Freightliner
The US truckmaker (owned by Daimler) purchased Tesla's battery technology in 2010 to use in a new fleet of commercial hybrid-electric trucks.

Volkswagen
Germany's biggest carmaker hired Tesla cofounder Martin Eberhard in 2010 to lead its battery lab.

ALTe
Founded by three ex-Tesla execs in 2008, this company gives old gas-guzzlers EV makeovers.

dramatically pulled a silver sheet off the car, it sparkled under white spotlights.

Musk got behind the wheel and drove guests up and down the street. The car impressed. It featured a sleek 17-inch touchscreen on the centre console and, since it lacked a combustion engine, there was room under the bonnet for a spacious storage area. The battery pack was flat, rectangular, and tucked under the floorboard, which meant it didn't infringe on the passenger space, giving the car a nice, open feel. And with the cargo area in the front, there was space in the rear for an extra row of seats facing backward. Just as Musk had asked: room for seven. Removing the design constraints of a combustion engine opened up the sedan to new possibilities.

The turnaround continued. Three months after the Model S unveiling, the US government announced it would lend Tesla $465 million to bring the sedan to market as part of the Advanced Technology Vehicles Manufacturing Loan Program. But there was a hitch: the money wouldn't be disbursed until he found a place to build the car.

One morning this April, Musk walked out of his Bel Air house wearing a tie covered in fake blood. Deepak Ahuja, Tesla's CFO, was flabbergasted. For days, the team had been preparing for a breakfast meeting with Akio Toyoda, exchanging emails on the fine points of Japanese business etiquette. Now, minutes before the Toyota president's arrival, Musk was wearing a Halloween joke tie emblazoned with skeletons and gore. He was going to ruin everything.

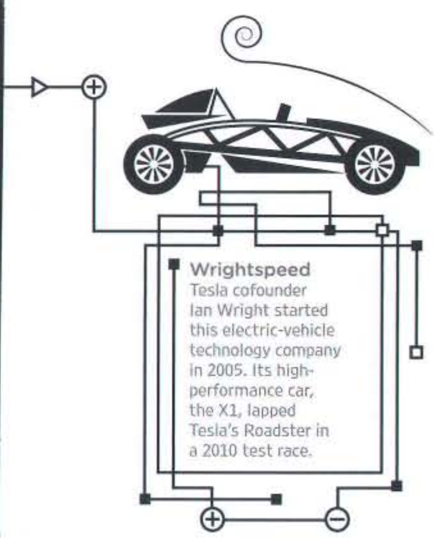
Ahuja glanced nervously at Diarmuid O'Connell, Tesla's vice-president of business development. O'Connell didn't know what to say. They stood awkwardly for a moment in front of the house while Musk started tapping out an email on his iPhone.

Then Musk looked up at them and broke into a broad smile. "I got you!" he blurted and started laughing. Musk wanted to diffuse the apprehension of meeting the president of the world's largest carmaker, and the bloody tie seemed to do the trick. Ahuja and O'Connell started laughing, too.

Musk took the tie off as a convoy of Toyota Sienna minivans and a Lexus limousine pulled up his driveway. Bodyguards stepped out of the vehicles, followed by a flood of Toyota executives. For a moment, nobody knew what to do. Toyoda had called the meeting to discuss "business opportunities", but nobody had met him before.

O'Connell spoke up first and introduced Musk. Toyoda stepped out of the crowd and everyone started shaking hands.

Toyoda saw Musk's Roadster in the drive, and the conversation turned to the car.



Wrightspeed Tesla cofounder Ian Wright started this electric-vehicle technology company in 2005. Its high-performance car, the X1, lapped Tesla's Roadster in a 2010 test race.

"Take it for a spin," Musk offered.

In a matter of minutes, the 53-year-old Toyoda had the accelerator floored, pinning Musk's head to the seat. Toyoda was a certified Toyota test driver and had competed at the 24-hour Nürburgring endurance race in Germany. Musk could tell. Toyoda chatted in a relaxed way as he whipped the car around corners in the hills above Sunset Boulevard. Toyoda said he wanted his company to be more entrepreneurial. That's why he had wanted to meet Musk and give the Roadster a try. He liked the fact that Musk had managed to bring the vehicle to market. Plus, it seemed like a fun car.

When they got back to Musk's house for breakfast, Toyoda cleared his schedule for the morning and got back in the Roadster with Musk. He wasn't done driving the car.

Toyoda piloted them on to the 405 freeway. They sped south, toward SpaceX, while Toyoda's fleet of minivans attempted to keep up. At the rocket factory, the two men hunched over Musk's computer and gleefully watched rocket-launch videos like a pair of 12-year-olds. It was a lot of fun.

Four weeks later, Toyota decided to invest $50 million in Tesla. The auto giant also signed on to develop prototype electric vehicles with the start-up and indicated it would support Musk's $42 million offer for the Nummi factory in Fremont.

During the press conference announcing the deal at Tesla headquarters, Toyoda took the microphone and talked about driving the Roadster and how it had impressed him. He decided to work with Tesla, he said, so that Toyota could learn from the small company's "spirit" and "energy". When asked by a Reuters reporter why he had chosen to partner with Tesla among all the electric-car start-ups, Toyoda looked over at Musk. "Musk-chan," he said. "I love him."

The clock is ticking. Musk says Model S production will start in 2012. To help him pull it off, Musk has hired an impressive roster of seasoned automotive engineers and manufacturing specialists. Gilbert Passin, the former Toyota executive in charge of the Nummi factory, joined Tesla in January. Peter Rawlinson, formerly a leading engineer with Jaguar and Lotus, is now Musk's top Model S engineer.

Rawlinson is tasked with finalising the sedan's specifications in advance of fabrication, and he hosts Musk's walkthroughs of Tesla's vehicle engineering department. This big, single-room office is filled with more than 100 engineers. Desks are clustered by subspecialty (aerodynamics, suspension, interiors). Rawlinson guides his boss to the "noise, vibration and harshness" team, whose job is to minimise all three attributes. The engineers replay their latest simulation, which shows that the Model S will be quieter and smoother on the road than most other cars.

Rawlinson's other engineers pull up simulations that show the car will feature superb aerodynamics, road handling and safety attributes. On the computer, the car performs better than an Aston Martin, costs significantly less and can stow a surfboard.

"I just hope we get good correlation with our predictive models," Rawlinson says.

ROADSTER 2.5

THE SPEC

Price: From £87,945
Range: 395 kilometres
Charging outlet: Standard UK 230-240V
Horsepower: 288
0–60mph: 3.9 seconds (3.7 with Sport package)
teslamotors.com

WIRED's verdict

With wicked acceleration and handling that borders on telepathic, Tesla's updated Roadster 2.5 is a joy to drive. It's especially fun with the £14,950 Sport package, which buys adjustable suspension, stickier tyres and acceleration boosted to the point where it can beat a Porsche 911 GT3 (until you hit the top speed of 200kph).

The car's massive 56-kilowatt-hour lithium-ion pack is good for 395km. And if you do ever drain it of juice, plug in and you'll be good to go in 3.5 hours. The Roadster remains the benchmark for EV range and performance, but it comes at a price. The souped-up model we drove topped £110,500. More than a Porsche 911 GT3. Or an Audi R8. Or... well, you get the point.

Wired Awesome acceleration. Amazing range. Sharp handling.
Tired Awesomely expensive. Tiny interior.
Chuck Squatriglia

In other words, Rawlinson hopes that they can actually build a car as cool as the one on their computer screens.

* * *

At the Nummi plant the following week, Musk dons a hard hat and surveys his new factory. A 20-metre-tall wrecking machine tears down a wall, making way for what will eventually be a Tesla assembly line. Right now, it's just a dusty pile of rubble.

Passin, head of manufacturing, leads the way into the plastics factory, a separate building filled with hulking bumper-making machines. The contraptions are so big, Musk and four Tesla execs walk inside one to inspect it. They're surrounded by metal walls designed to slam together to mould bumpers. The walls far apart, but there is a sense that they could pound in at any moment. It feels like standing inside a gargantuan waste compactor.

Musk seems to like the space. "The great thing about this place is it sets us up for the next generation after the Model S," he says. "We could have 250,000 cars coming out of here in five years."

That is, if Musk can pull off the Model S. The factory is set up to produce cars made of steel and uses magnets to position parts. To cut down on weight, the Model S will be built out of aluminium, which isn't magnetic. Passin plans to retro-fit machinery with suction cups to work around this. There are other obstacles: Tesla has to hire workers, deal with the unions and wrangle parts suppliers. And if and when the Model S does roll off the line, Tesla will have to face a marketplace crowded with electric-car competition from big-league manufacturers such as GM and Nissan.

None of this seems to bother Musk. Tesla's financial situation has turned around, he explains. He now has the capital and the infrastructure to transform the company.Not that the road ahead is smooth. "I'm not staring into the abyss of death any more," Musk says. "I'm just eating glass now." W

Joshua Davis (joshuadavis.net) wrote about flushless urinals in issue 08.10

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THE 11.10 COLOPHON

THIS MONTH...

Overheard in the WIRED kitchen: "Welcome to the gun show. Have you met my friends, Thunder and Lightning?"

"I pronate like a madman."

"Sorry, I can't do it, I have to go to the alcohol-testing facility."

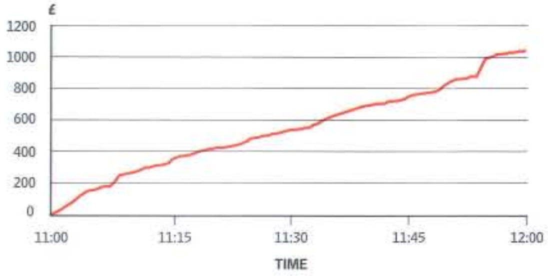
Dark days at WIRED – the July-August honesty tin for coffee:

Pods consumed: 676. Cost of pods (@30p): £202.80. Amount in tin: £158.35 (£44.45 short). Honesty quotient: -0.219

Modal coin: 20p (157). Least occurring legal tender: 2p (16).

Disappointing data. If pods were still 25p, we would have been £10.65 short (better). There's a tea leaf in the coffee cupboard.

Our faith in humanity was restored by our readers' response to a WIRED online appeal to raise £1,000 in an hour for Care International UK's Niger fund. Starting at 11am on September 3, we breached the four-figure mark six minutes ahead of schedule (*below*). Charity begins online. Thank you to everyone who gave.



Farewell to Nicola Day, the publisher's assistant and curator of WIRED Insider, who's been with WIRED since launch.

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Sources for the WIRED Index (page 33):
[1] , [2] CB Insights' "Venture Capital Human Capital Report", January-June 2010 **[3]** Nasa communication, August 6, 2010 **[4]** *Wall Street Journal*, August 1, 2010 **[5]** "Top Secret America" in *Washington Post*, July 2010 **[6]** Agence France Presse report, August 8, 2010 **[7]** Lisa Page et al "Frequency and predictors of mass psychogenic illness" in *Epidemiology*, September 2010

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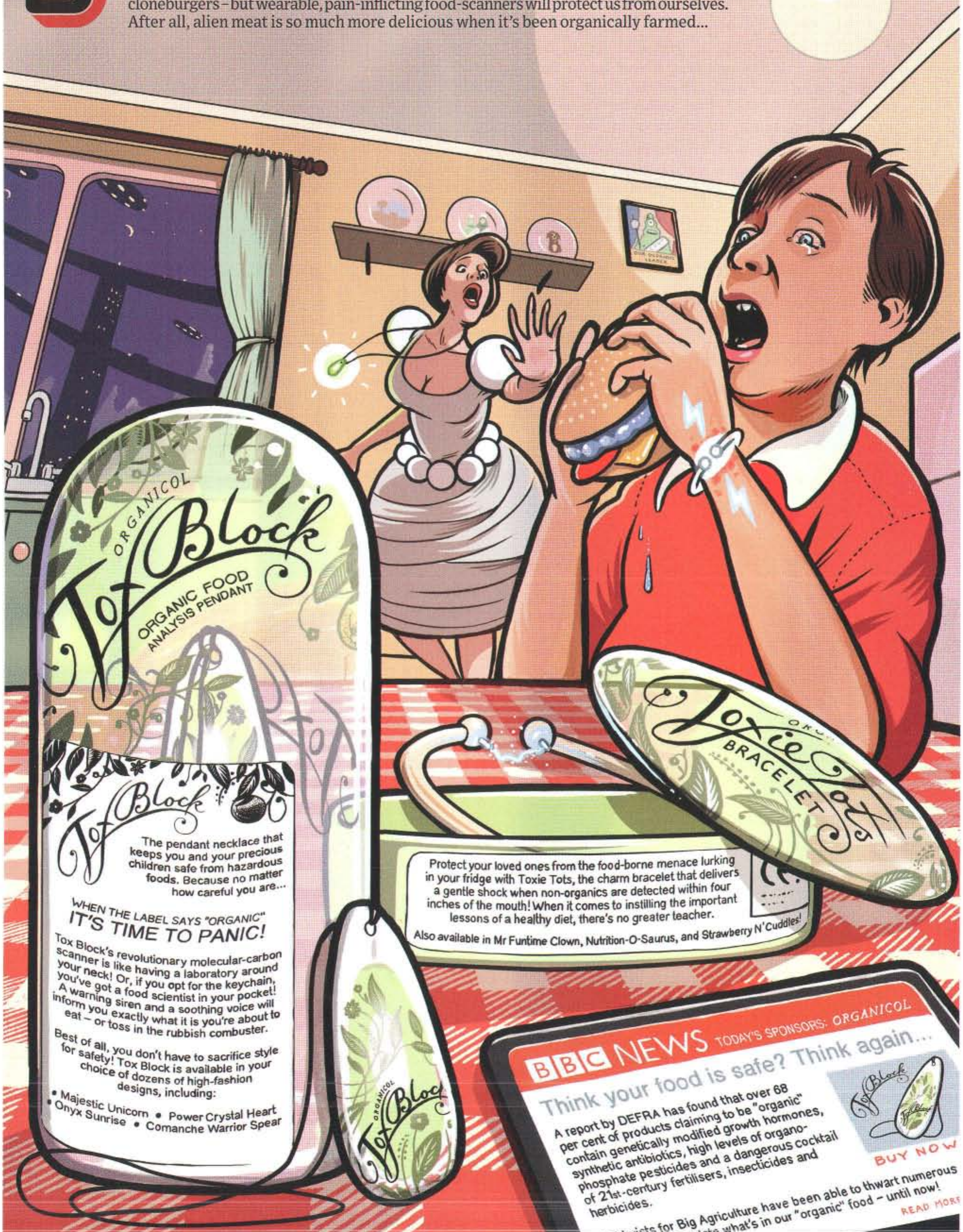

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